

perfectly solid. This indicates that the outside layer is at once condensed by cooling, while the inside remains fluid, and is consequently more distended. Though the outside of the drop is very hard, and a severe blow may be struck upon the thick part without any perceptible effect, if the tail or thin end is broken the whole mass instantly flies to pieces with a slight detonation. Dumas explains these phenomena by stating that when at last the central and dilated parts of the drop become cooled they must have retained points of adherence to the surface, and consequently occupy a larger volume than that which agrees with the temperature to which they are reduced. The central molecules, therefore, must be much distended and exert a more powerful contracting influence on the surrounding parts; are, in a word, "on a strain," as a workman would term it. At the instant when a part of the envelope or outer portion is broken the molecules held by it briskly contract, draw in with them all the others, and thus determine a multitude of points of rupture; and as this effect is instantaneous, the particles move very rapidly and drive out the air before them, producing a sudden dilation and contraction of the latter.

**BASTIE'S TEMPERED GLASS.**—In view of these well-known phenomena, M. de la Bastie endeavored to find a method by which the hard surface produced by immersion in water could be retained and thickened while the objectionable tendency to flying in pieces would be lessened or removed. In his experiments he found that two conditions were necessary: first, the glass must be brought to just that degree of heat where softness or malleability begins, the molecules then being capable of closing suddenly together and condensing the material when immersed in a liquid at a considerably lower temperature; second, the liquid employed must be capable of being heated much higher than water without boiling. He therefore adopted an oleaginous mixture, into which he plunged the glass, reheating the latter, which had previously been annealed in a kiln.

**DIFFICULTIES OF THE PROCESS.**—This process was admittedly a success as far as flat or solid glass was concerned, although the necessity of heating the glass to the point of softening rendered it extremely difficult to handle, and the liability of the bath to catch fire had to be lessened in some manner; but both these difficulties were overcome by M. de la Bastie's apparatus for reheating and plunging the glass. The process, however, was found to be defective as regards any other forms of glass, such as hollow flint vessels, as such glass, while being reheated, is almost certain to collapse before reaching the required temperature. In M. de la Bastie's experiments at Whitefriars glass works, England, therefore, a new plan was adopted, by which the bath was placed as near the mouth of the working pot as possible, and the workmen dropped the finished vessels directly into it. This process was found to answer well in the manufacture of all vessels made in one piece, and the somewhat complicated apparatus for reheating was done away with. As regards the character of the glass obtained by the process, Mr. Powell, of the Whitefriars works, disposes of some popular fallacies in this wise:

Hardened glass is not unbreakable; it is only harder than ordinary glass, and, though it undoubtedly stands rough usage better, it has the disadvantage of being utterly disintegrated as soon as it receives the slightest fracture, and up to the present, until broken, of being undistinguishable from ordinary glass. This glass is known as "toughened" glass, and we have seen the terms "malleable" and "annealed" applied to it. Nothing can be more misleading than these unfortunate epithets. The glass is hard, and not tough or malleable, and is the very opposite to annealed glass. Annealed glass is that glass the molecules of which have been allowed to settle themselves; the molecules of hardened glass have been tortured into their position, and until the glass is broken are subject to an extreme tension. It is the sudden change of temperature that "hardens"; glass heated up together with the oil may be annealed, but decidedly is not hardened. A piece of hardened glass is only a modified Rupert's drop, *i. e.*, it is case-hardened; the fracture of both is identical; both resist the diamond and both can be annealed. \* \* \* In our experiments we found that while the glass could be marked with the diamond or smoothed and engraved in the ordinary way, still an endeavor to cut it with the diamond, or even the disturbance caused by the smoothing-wheel, when penetrating to any appreciable depth, tended to weaken or even to cause the destruction of the entire mass.

For practical utility the value of glass tempered by M. de la Bastie's process is of course impaired by its inability to be cut, and also its utter destruction by the slightest fracture. It will stand sudden changes of temperature without breaking, but if reheated slowly to a high temperature its temper is destroyed and it becomes as common glass. The great anticipations which were at first formed as to the extended use of the glass have not been realized. M. de la Bastie has made some improvements in his process, and two eminent London firms adopted it and manufactured the glass for a time, but finally gave it up. In this country Messrs. E. de la Chapelle et Co., of Brooklyn, manufacture on the Bastie system, but the process is not a complete success, the glass not being uniform in temper or producing the best results.

**SIEMENS' TEMPERED GLASS.**—While M. de la Bastie was introducing his discovery to public notice in Europe Mr. Frederick Siemens, who is owner of the most considerable glass-bottle works in Germany and Bohemia, and perhaps in the world, was studying the question of tempering glass by following a different course from that selected by the former. Instead of plunging hot glass objects into liquids, Mr. Siemens, fearing distortion of the articles to be treated, conceived the idea of subjecting them to tempering by placing them in molds between cooled surfaces, whereby not only would their shape be maintained intact, but force could also be applied, if necessary, to press the molecules of glass firmly together. By these means glass of any shape could be tempered, and the process was considered to be particularly well suited for the production of strong window-glass, which had not previously been attempted. Mr. Siemens, however, soon found that the glass so prepared was liable to the defect of breaking suddenly, and he had to undertake further researches, with a view of perfecting his process, by the removal

of that defect. When a cube of tempered glass is considered, it will at once be seen that, all its surfaces having been subjected to the same cooling influence, the edges, and particularly the corners, will be much more cooled than the broad surfaces. At each edge the cooling will take place from two surfaces, and at each corner from three surfaces, from which circumstance Mr. Siemens inferred that glass so treated could not be homogeneous in character, and that sudden breakages were due to that cause. To overcome this defect Mr. Siemens modified his process so as to limit the cooling influence of his apparatus to two surfaces of the glass under treatment. From these surfaces the cooling and tempering action is transmitted to the center of the mass in a uniform manner, whereby homogeneous glass is produced which is found to give entire satisfaction. By Mr. Siemens' process glass may be tempered to various degrees of hardness, according to the use for which it is intended. For the production of window and other flat or molded glass presses, cooled by the circulation of water, are employed, but in dealing with large castings of glass, such as railway sleepers, for example, the castings are packed in rectangular boxes, or trucks, heated internally for their reception, and all interstices between them are filled up with a material having the same conductivity for heat as glass. These boxes or trucks are constructed so as to prevent dispersion of heat at their sides, and as each is filled with glass articles it is withdrawn from the kiln to cool from two parallel surfaces only. By this means ideal plates are formed, which are treated like the solid plates for the production of homogeneous tempered glass in bulk. Glass railway sleepers, tempered on Mr. Siemens' plan, have been introduced in England, and have been put in actual use on one or two railway lines.

**TESTS OF THE SIEMENS' GLASS.**—A number of tests were made of these sleepers, at one of which it was shown that their average breaking weight, when resting on supports 30 inches apart, was 5 tons. At another time a plate of Mr. Siemens' toughened glass, 9 inches square by  $1\frac{1}{8}$  inches thick, imbedded in gravel ballast 9 inches deep, and having on its top a wood packing one-eighth of an inch thick and a piece of rail, was subjected to the action of a falling weight, the blows being delivered on the rail. The weight was 9 hundred-weight, and blows were successively delivered by letting this weight fall from heights of 3 feet, 5 feet 6 inches, 7 feet, 10 feet, 12 feet 6 inches, 15 feet, 17 feet 6 inches, and 20 feet. Under the last-mentioned blow the rail broke, the glass, however, being uninjured. A higher fall could not be obtained, and a greater weight was not available. A smaller section of rail was substituted for that previously employed, and the glass was broken by the second blow of the 9 hundred-weight falling 20 feet, the plate being driven through the ballast into the hard ground. A cast-iron plate, 9 inches square and one-half an inch thick, tested in a similar way, broke with a blow from the 9 hundred-weight weight dropped 10 feet.

**USES OF SIEMENS' GLASS.**—Mr. Siemens writes me, under date of January 29, 1881:

Extensive works are about to be established in England for carrying out my process and for producing the glass to be tempered. These works will at the start comprise furnaces capable of producing 50 tons of glass per day, and will be arranged in view of being doubled and trebled in a short time, it being confidently expected that a large demand will arise for strong glass as a substitute for wood, brass, cast-iron, stone, and other substances, in the condition of railway and tramway sleepers, gas-, water-, and drain-pipes, eave troughs and gutters, millstones and crushers, tiles for roofing, facing walls and flooring, plates for floors of bridges, tanks, and cisterns, ship lights, telegraph insulators, etc., for which applications tempered glass will offer the advantages of economy in first cost and greater durability over the materials now usually employed.

**COST OF SIEMENS' GLASS.**—The cost of glass toughened on Mr. Siemens' plan is stated to be about the same per ton as that of cast-iron; but as its specific gravity is only about one-third that of iron, the cost of any article of given dimensions is, of course, materially less. The material has as yet been too recently introduced, and too little is known of its characteristics, to enable any very decided opinion to be formed as to its future capabilities; but the results of the experiments so far made are certainly of a very promising character, and the further development of its application will be watched with much interest.

**GLASS FROM BLAST-FURNACE SLAG.**—The process of manufacturing glass from the waste cinder or slag of iron blast-furnaces is simply the utilization of a substance which already contains many of the ingredients of glass by adding to it those materials necessary to complete the composition. The idea is not a new one. In England, and also on the continent, a sand prepared by pulverizing slag has long been used as an ingredient in glass-making with much success. It is possible that much of the early glass was metallurgical slags remelted.

**RELATIVE COMPOSITION OF GLASS AND SLAG.**—Recent comparative investigation into the composition of glass and of slag shows that the use of the latter in this manner is not without reason, the two substances being very similar, as is shown by the following table:

Constituents.	Composition of iron slag (Welsh or South Staf- fordshire).	Composition of bottle-glass (quantities va- riable).
	<i>Per cent.</i>	<i>Per cent.</i>
Silica .....	40	45 to 60
Lime .....	33	18 to 28
Alumina .....	16	6 to 12
Magnesia .....	6	0 to 7
Alkali .....	$\frac{1}{2}$ to 2	2 to 7
Oxide of iron .....	$\frac{1}{2}$ to 2	2 to 6

A trace of sulphur is also found in slag associated with the lime, but this readily passes away with heat, and is insignificant. The iron, which would seem to be the most objectionable element, while present in too great quantity for the manufacture of perfectly clear glass, is still less than is often required by the glass-maker. The chief points of difference between the slag and the glass are in the silica, alkali, and iron, the slag being too deficient in sand to make a hard glass.

ADDITIONS TO SLAG IN THE MANUFACTURE OF GLASS.—To make glass of slag of the composition given the additions indicated in the following table should be made:

Slag.		Additions.		Glass.	
Silica.....	40	Ferruginous sand.....	60=100	or 57.14	per cent.
Lime .....	35			35	or 20.00 per cent.
Alumina .....	16			16	or 9.14 per cent.
Magnesia .....	6			6	or 3.43 per cent.
Alkali .....	1	Soda .....	10=	11	or 6.29 per cent.
Oxide of iron.....	2	From the sand.....	5=	7	or 4.00 per cent.
	100		175	100.00	

Thus by combining with 100 parts of slag 10 parts of soda and 65 of sand the proportions of the lime, alumina, and other constituents are severally altered, and a compound formed of the precise nature required. It is to be noted that the figures come well within the limits of difference found in the analyses of glass given in the previous table. It would seem that the variation in the purity of the slag would interfere with certainty in its use; but daily analyses of slag at a furnace in Great Britain have shown that its composition is measurably regular, enough so for all practical purposes.

USE OF HOT SLAG.—To take slag, however, which has cooled, and remelt it in connection with the additions named, would require so intense a heat as to counterbalance all benefit to be derived from its cheapness. A plan was brought to public notice in England in 1876 by which the slag is taken as it comes from the blast-furnace and converted into glass without cooling. Mr. Bashley Britten, the originator of this plan, has established glass works at Finedon, in Northamptonshire, at which the slag from the Finedon furnaces is used. The molten slag is conveyed (presumably in covered iron vessels mounted on wheels) to the glass furnace in the immediate vicinity, and is poured, after the addition of the necessary ingredients, directly into the melting furnace, where, after proper fusion, it is run into another chamber, from which it is drawn by the workmen and fashioned into shapes. The products of these works comprise chiefly such articles as wine and beer bottles, which do not require a colorless glass. This process might be much improved by locating the glass house immediately adjacent to the blast-furnace, from which the slag could be run directly into the melting furnace. In regard to the great economy of the process, Mr. Britten says, (a) referring to the table given above:

The above 175 parts or tons of glass would, consequently, be produced with the following economy: One hundred tons of it would cost an iron-master nothing. Instead of the labor of mixing and handling in the usual way the whole quantity of the material, only 75 tons would have to be lifted into the furnace. The only ingredients to be bought are 65 tons of common yellow or red sand, to be had anywhere at a mere nominal price, and 10 tons of common sulphate of soda, which may be bought or made for about 20s. per ton. The necessary fuel would be limited to what is needed beyond the surplus heat of the slag to raise only three-sevenths of the glass to the required heat; and it is a question whether the greater part of even this might not be saved by bringing down some of the spare gases from the blast-furnace and employing them with regenerators; if needed, they could easily be enriched with a little added carbon. Against these items there would be a set-off from the cost of removing the 100 tons of slag, which must otherwise be thrown away. Beside this, another and considerable saving would arise from the wear and tear of the glass furnace being lessened, in consequence of four-sevenths of the materials going into them being already fused. Under such circumstances the total cost of the glass in a melted state ready for working is seen to be so extremely small that it is hardly safe to venture to express it in figures; it scarcely amounts to the value of the commonest bricks per ton.

COLOR OF SLAG GLASS.—The natural tint of the glass thus produced is greenish, but it can be colored to any required tint, and by careful fining and bleaching it can be produced almost as colorless as common window-glass. A cheaper glass can be made by using more slag and less sand, and with some ores the slag is said to be sufficiently siliceous in itself to be converted into a black or dark green or amber glass. With the simple addition of soda and a little arsenic it becomes transparent and perfectly workable, and may be used for many purposes. Acid, however, corrodes this glass, on account of its want of silica. Glass of superior quality to the first mentioned can also be produced. The constituents of slag, as has been seen, are common to all kinds of green glass, and by diluting them with the usual pure materials to a greater or less extent the compound may be brought up to any standard short of the purity of color inconsistent with the iron and sometimes manganese in the slag. Should the manufacture of glass in this manner ever be deemed of sufficient importance to warrant the taking of steps to purify the slag, much more might be accomplished. The working qualities of the glass thus produced are excellent, admitting of its being blown, cast, or pressed with great ease, and Mr. Britten's company propose to enter into the manufacture of other articles beside bottle from a material so cheaply produced.

a See his paper in *Journal of British Iron and Steel Institute*, 1876, pages 453-467.

## CHAPTER VIII.—HISTORY OF SOME PROCESSES OF GLASS-MAKING.

For many years the question as to whether window-glass was known to the ancients was a matter of doubt and discussion, and it has only been recently that the evidence of its use prior to the beginning of the Christian era has been conclusive. Winckelman, the author of the remarkable *History of Art*, who was assassinated in 1768, pleaded its antiquity, but by far the greater number of scientific men considered it a modern invention, their view being strengthened by the almost utter absence of any allusion by ancient writers to window-glass and the utter lack of fragments of this glass, though large quantities of pieces of vases and other vessels had been found. This want of allusion and absence of remains shows that at least it was of rare occurrence and use.

The first positive evidence of the antiquity of window-glass was its discovery, in the year 1763, in a small chamber attached to the bathing-room of a private dwelling, the House of the Faun, unearthed at Pompeii, "in a window closed by a movable frame of wood, which, though converted into charcoal, still held when it was found four panes of glass about 6 inches square." In 1824, in a room connected with the public baths, "a window 2 feet 6 inches high and 3 feet wide, in a bronze frame, in which were found set four beautiful panes of glass fastened by small nuts and screws, very ingeniously contrived with a view to being able to remove the glass at pleasure," was discovered. Remains of what is supposed to be window-glass of the Roman period are now occasionally found in the ruins of Roman houses built in England and Italy. Dr. Bruce, in his work on the Roman wall, states that "fragments of window-glass are frequently found at some of the stations", and in 1855 he exhibited at Newcastle samples found in the course of his excavations at Brementium. It is also certain now that glass was used by the Romans for green-houses and for the frames used over plants. The glass found at Pompeii shows by chemical analysis a very close resemblance to the glass of modern days, containing about 69½ per cent. of silica, 7½ per cent. of lime, and 17½ per cent. of soda, with 3½ per cent. of alumina. This glass also contained 1.15 per cent. of oxide of iron and 0.39 per cent. of oxide of manganese, the latter being used probably to correct the color due to the iron.

It must not, however, be supposed that glass was used to any great extent in the windows of dwelling-houses at this time. The glass was not blown, but probably cast on a stone, as it is very uneven and full of defects.

Before the close of the third century, however, window-glass begins to be mentioned in the writings chiefly of the monks and priests of the time, and mainly in connection with the glazing of churches. About this time reference is made to window-glass by Lactantius, A. D. 290, who says that "our soul sees and distinguishes objects by the eyes of the body as through windows filled with glass". Jerome, A. D. 331, speaks of sheets or plates of glass obtained by casting, the casting-table being a large flat stone, and the ordinance of Constantine II, A. D. 337, mentions *specularii*, who were probably glaziers working in other materials as well as in glass.

From this time the evidences of the use of window-glass multiply. It is reasonably certain that it was employed in the church at Treves early in 420. During the fifth and sixth centuries many large churches were built at Rome and Ravenna which were filled with numerous windows, and in the sixth century the glazed windows in the church of Saint Sophia, at Constantinople, with panes from 7 to 8 inches wide by 9 to 10 inches high, were among the wonders of the East. Indeed, it was the building of churches, or the conversion of pagan temples into houses for Christian worship, that extended the use of window-glass at that time. The Roman priests kept the windows and sometimes the roof of the buildings open to read the auguries, but these the Christian priests closed.

Window-glass was used in France as early as the third century, but became more common in the sixth. Late in the seventh century "Abbot Benedict", so saith the venerable Bede, "sent for artists from beyond the seas to glaze the church and monastery at Wearmouth," and York cathedral was glazed about the same time. In the eleventh and twelfth centuries glass was generally employed in the windows of the religious edifices, and it is reported that somewhere about the end of the first thousand years of the Christian era a window-glass works was established at Newcastle-on-Tyne, which proved a failure. From the close of the twelfth century the use of glass for windows became more and more common.

The earliest glass used for windows was undoubtedly cast, that used at Pompeii having evidently been cast on a stone, on the same principle as plate-glass is made at the present time, only it was not polished. It thus appears that, though rough cast plate-glass was for a long time believed to be a modern invention, it really is the oldest method of making glass for windows. This was, however, probably in the twelfth or thirteenth century, or perhaps earlier, abandoned for blown window-glass, and was revived and virtually rediscovered in France in 1688 by Abram Thevart. He obtained a patent for thirty years for the invention, and erected works in Paris, where plates were cast of the then extraordinary dimensions of 84 inches long by 50 inches wide. This works was transferred to Saint-Gobain, which has since become celebrated for its plate-glass. Disputes arose between Thevart's company and a company of Venetian workmen who were manufacturing blown plates near Cherbourg, and Thevart's company was bound not to cast any plates whose dimensions should be less than 60 inches in length and 40 in breadth. To end the rivalry the two companies were consolidated. Two years, however, from the consolidation



the company was in a state of insolvency, and many of its furnaces were abandoned. Blancourt gives a different account of the invention of plate-glass, and ascribes it to the accidental spilling of some liquid glass from a crucible upon the ground. The metal having run under one of the large flat stones with which the place was paved, upon taking up the stone a piece of plate-glass was found under it. This is stated to have been two hundred years before Blancourt wrote in 1699. The first English establishment of any magnitude for the manufacture of glass was begun in 1772 or 1773 at Ravenshead, at which date "the Governor and Company" "of the British Plate-Glass Manufacturers" were incorporated for the purpose of manufacturing plate-glass in England, and as late as 1832 this was the only establishment in that country. Since that time, however, a number of works have been established. The oldest plate-glass works in Belgium, we believe, dates from near the beginning of the present century, while that of Germany has been in existence but a few years.

As noted, it is very difficult to say when blown window-glass was first made; but one of the earliest notices of it is by the monk Theophilus, in the thirteenth century, who, in his *Essay on Divers Arts*, gives an account of a method then employed of blowing glass, which is a perfect description of that used at the present time. For many years the factories at Venice were renowned for their blown window-glass, and in the seventeenth century workmen from its houses were scattered in various parts of Europe and taught many of the glass-workers of the different countries the method of making cylinder-glass. Nesbitt also states that window-glass was made in Germany at a very early period, and it also seems, from a statement quoted elsewhere regarding the windows of Beauchamp chapel at Warwick, that window-glass was made in England, probably blown, in the fifteenth century. Mr. Chance states that the manufacture of blown window-glass in England existed in the fifteenth century, and perhaps even prior to that period; but the glass then produced was of a very inferior description, and the first works of note established in England were those of Sir Matthew White Ridley & Co., on the river Tyne, at Newcastle, about the middle of the seventeenth century.

VASES, CUPS, AND OTHER HOLLOW WARE.—As has already been noted, the earliest records of glass-making (those on the tombs of Beni-Hassan and at Memphis) show unmistakably that the art of glass-blowing was well known at the early period at which these tombs were built. One of these figures illustrates two glass-blowers, with their blowing irons or rods in their hands, heating the glass, which has evidently been gathered, in a small U-shaped furnace. Another drawing represents two men blowing a vase.

From that day to this the production of various kinds of hollow ware has not ceased. An immense number of articles of this character, including vases and cups of all sizes and almost all shapes, from those of the most common description to others showing the most exquisite art, as instanced in the Portland and the Naples vases, and bottles of all forms and decanters, have been found. Indeed, so common and persistent has been the manufacture of these various articles, that the history of ancient and modern glass is chiefly the history of the manufacture of hollow ware, and, as we have entered so fully into the statement, nothing more need be said here.

LEAD GLASS.—The invention of what was so long known as flint-glass, and now generally termed lead flint, to distinguish it from the lime flint of the glass houses of to-day, is an English invention. Its production was a necessity arising out of the use of coal in the place of wood in the furnace. This substitution of coal for wood affected injuriously the color of the glass, and to overcome the pernicious effects of the smoke the melting-pot was covered with a clay cap, which gave it the shape of a short-necked retort. It was found, however, that though the metal was protected from the action of the smoke, it was also protected from the action of the heat, and it became evident that either the time of melting, as well as the consumption of fuel, must be very much greater, or some flux or alkali must be used which would not deteriorate the glass, but hasten its melting. The flux used was lead, which had to a slight extent been employed on the continent of Europe for some time previous in the manufacture of artificial gems: a use which may probably have suggested its employment for the making of flint-glass. The use of lead, however, in the manufacture of glass was not entirely unknown before, as lead is found in many specimens of ancient glass, and Heraclius gives a recipe for making glass with lead. There was also a glass, known as the Jewish, made with lead in the Middle Ages. M. Peligot, however, reviewing these facts, comes to the conclusion that there is no proof that the true flint-glass was known to the ancients, and that to the English should really be attributed the honor of having created in their flint-glass a new product, which, by the progress made in the quality and selection of the materials used in its fabrication, has become without dispute the most beautiful glassy substance which we know, and which it may be possible to produce.

The date of the introduction of the manufacture of flint-glass with lead is placed by M. Bontemps about 1635; Nesbitt suggests that it may have been 1615.

THE USE OF MOLDS is generally believed to have been a comparatively modern invention; but, as is shown in the chapter on ancient glass, it is evident that some of the vases used in very remote times were not blown, but were cast or molded over a sand or clay core, which was afterward broken up. It also seems that the so-called Roman molded glass, which was supposed to be a modern invention, was well known to the Romans, as specimens exhumed in the city of London prove. At what time, however, the modern method of using molds in the production of various forms of hollow glass was first introduced is not known, though it is evident that the use of these has largely increased within the years since the introduction of the use of the lever-press for molding or pressing glass.

**PRESSED GLASS.**—One of the most important inventions of recent times, especially in the line of cheapening glassware, has been the production of what is generally known as pressed glass. This is an American invention, and the right of this country to the honor of its production has not been called in question until recently. Lardner, in his *Cabinet Cyclopædia*, published in 1832, which has a very complete *résumé* of the methods of making glass in use at that time, has not even a suggestion of the pressing process. Pellatt, in his *Curiosities of Glass-making*, published in 1849, says :

The invention of pressing glass by machinery has been introduced into England from the United States of America. It has not, however, realized the anticipations of manufacturers; for, by the contact of the metal-plunger with the glass, the latter loses much of the brilliant transparency so admired in cut-glass; hence it is now chiefly used for common and cheap articles. The process of rewarining or fire-polishing after the pressure has somewhat remedied this defect.

Recently, however, an attempt has been made to deprive the American glass manufacturers of the credit of this invention. The *London Pottery Gazette*, in a recent issue, says :

There seems to be a general impression that pressed glass was first made in the United States. This is an error. The addition of the ring to give the thickness was undoubtedly an American invention; and this discovery, trifling in itself, opened up the pressed trade in a remarkable way by enabling the lever used in modern pressing to force up the metal sharply, so as to give it the appearance of cut-glass, as well as to closely imitate cut-glass patterns.

Many in the English glass trade are living who remember the pressed square-footed ales and goblets. These are as old as the end of the last century, and were very fashionable with our ancestors. At first they were cut over, but they perfected the make so that they were simply cut at the bottom to take off the overplus.

**ANCIENT PRESSED GLASS.**—It is undoubtedly true that glass was pressed before the invention of the American lever-press, and one of the earliest specimens, bearing an inscription from which its date may be ascertained, is the lion's head, now in the Slade collection in the British museum, which was found many years ago at Thebes. This is evidently a piece of pressed glass, or glass pressed in a mold. In the British museum are also many pieces of glass found at Ialysos, in Rhodes, chiefly disks, all of which have evidently been produced by pressure with a mold or die. There is no doubt that the Venetians were acquainted with pressed glass; but, notwithstanding this, the invention of what is now known as pressed glass is undoubtedly American. The same line of reasoning that is adopted to prove that this is not an American invention would also prove that lead-flint glass was not an English invention. Lead was used to make glass centuries before the invention of lead-flint in England, but the English are none the less entitled to the credit of the discovery of that beautiful, brilliant ware that we know to-day as lead-flint glass. Glass was no doubt made by pressing many centuries ago, but the invention of pressed glass, as it is understood to-day, the use of a mechanical press with mold, plunger, lever, etc., is due to American ingenuity. Pellatt, when referring to specimens of the embossed and pressed glass of the ancients, says: (a) "No machinery was used by them in producing any completely pressed hollow vessel or utensil at one operation." It occurs to me that if Mr. Pellatt, with all of his knowledge and information regarding ancient glass-making and his years of practical connection with the business in England, ascribes the invention of modern pressed glass to Americans, his testimony cannot be impeached.

**HISTORY OF THE INVENTION.**—The invention of the American press is ascribed to a Massachusetts carpenter in the town of Sandwich, about 1827, who, wanting an article of glassware made for some purpose, went to Mr. Deming Jarves and asked him if he could make the article desired. Mr. Jarves told him that it would be impossible for the glass-blowers to make such an article. The carpenter, who was of a mechanical turn of mind, asked if a machine could not be made to press glass into any shape. This idea was scouted at first, but upon second thought Mr. Jarves and the carpenter fashioned a rude press and made their first experiment. This machine was intended to make tumblers, and when the hot molten glass was poured into the mold, which was to determine whether glass could be pressed, the experiment was witnessed by many glass-makers of that time. They were nearly all of the opinion that the experiment would come to naught, and were greatly amazed when the result demonstrated that it was possible to press glass. From that time the manufacture of articles of glass by the use of pressing machines gradually developed, until to-day the bulk of the glassware produced in this country is made with presses. The first tumbler manufactured in the rough improvised press, alluded to above, remained in Mr. Jarves' possession for many years, and then passed into the hands of John A. Dobson, a well-known glass dealer in Baltimore, and was exhibited at the Centennial Exhibition by Hobbs, Brockunier & Co., when it was accidentally broken by Mr. John H. Hobbs.

The *London Pottery Gazette*, to which we have referred above, in an article claiming the invention of pressed ware for England, says: "The first pressed tumbler was undoubtedly English, and was made about 1836." As Mr. Jarves made his pressed tumbler in 1827, as described above, we think that the evidence is conclusive that the first pressed tumbler was not English, but American.

The result of this American invention in cheapening glass has been most marked. By the use of iron or other metal molds immense quantities of the same article can be produced at a very low rate. This invention has in fact revolutionized the whole system of flint-glass manufacture, and has made it possible for all to possess for common use glass that in gracefulness of form and beauty of design and material was formerly within the reach of only the most wealthy.

a See Pellatt's *Curiosities of Glass-making*, page 122, note.

## CHAPTER IX.—ANCIENT GLASS.

**DISCOVERY OF GLASS.**—But little is known of the early history of glass-making, and absolutely nothing of the method and date of its discovery. The story told by Pliny, (*a*) and repeated substantially by Tacitus (*b*) and by Strabo, (*c*) of its accidental discovery by some storm-driven Phœnician mariners while cooking their food on the banks of the river Belus, (*d*) is not entitled to the least credence. It is impossible that the high temperature necessary to the production of glass could have been obtained in the manner described in these fables. It is true, however, that a small spot at the mouth of this river supplied a most excellent sand, which was used not only by the Phœnicians, but by many other ancient glass-workers, and even by the Venetians in latter times. This fact, coupled with the excellence of the Phœnician glass and the commercial enterprise of the people, which carried the products of their manufactories to all lands, may have given rise to the story related by Pliny, and thus for a time robbed the Egyptians of the credit of a discovery which is undoubtedly theirs.

**PROBABLE METHOD OF DISCOVERY.**—While nothing positive is known of the method of the discovery of glass, it is not improbable that it was in connection with the older art of metallurgy. (*e*) Many metallurgical operations produce in their vitreous slag a coarse colored glass that may have led to the manufacture of glass as a direct product. All of the oldest specimens of glass are colored, and, so far as these have been analyzed, the coloring matter is metallic. The extreme variability in the composition of this antique colored glass led Klaproth to the conclusion that many of the specimens are merely metallurgical slags remelted. It is also true that much of the ancient glass is "cast." These facts certainly indicate, if its discovery was not due to this older art, that metallurgy had an important influence on early glass-making.

**EGYPTIAN GLASS.**—The earliest evidences of the existence of the art of glass-making are found in Egypt. It is impossible, however, to surmise even at what time it began to be made in that country, aside from the certainty that the art antedates by many centuries the time of its earliest inscriptions and specimens. Egyptian chronology is so uncertain, that the same events are assigned by different Egyptologists to periods thousands of years apart. Inscriptions, paintings, and the glass itself, however, indicate its manufacture at least from 4,000 to 6,000 years ago. (*f*) Rawlinson, (*g*) a most conservative authority, states that "glass was known in Egypt as early as the Pyramid Period", which he places at 2450 B. C. (*h*) That at this early date the art of glass-making had reached a high degree of perfection and development seems beyond question. The art of blowing glass into bottles, fashioning it into vases and drinking-cups, pressing it into various shapes, especially figures of deities, sacred emblems and coins, forming it into huge masses for pillars, adapting it for mosaic art, coloring it to imitate precious stones, the color being of surpassing brilliancy, working it into beads or necklaces, these and similar processes were well known and practiced with great skill. It would seem impossible that the processes necessary to the production of these forms of glass could have been developed without centuries of practice. The invention of the art of blowing glass, which is unmistakably figured on the tombs of Mastaba of Tih, at Memphis, and on the tombs at Beni-Hassan, (*i*) is as remarkable as the discovery of glass itself, and would indicate an advance in the art that, in that day of slow development, must have required many centuries to evolve. The manufacture thus early begun was continued by Egypt far into the Christian era, and under the various dynasties and rulers, both native and foreign, it continued to flourish. When Egypt passed under the dominion of Rome, its glass houses found in the palaces and villas of the imperial city a larger and more profitable market for their wares, and even as late as the third century its glass works were still in operation, an ordinance of Aurelian providing that glass should form a part of the

*a* See Pliny's *History*, book xxxvi, chap. xxvii.

*b* *Histories*, book vi.

*c* *Geography*, book xvi.

*d* This river runs along the base of Mount Carmel, and empties into the Mediterranean near the modern city of Saint Jean d'Acre.

*e* Metallurgy is one of the arts the invention of which is ascribed by the Egyptians to Osiris, and while the first man was living copper and iron were melted and worked (Gen., iv: 22). Some writers incline to the opinion that the discovery of glass was in connection with the art of pottery in making the glassy glaze.

*f* Among the earliest traces of glass are those found in the ruins of Memphis, built by Menes, first king of Egypt, whose reign Manetho places at 5004 B. C. The mummies in the tombs of this city wear necklaces of paste-glass beads. Glass-blowing is unmistakably figured on the walls of the tomb of Mastaba of Tih, belonging to the fifth dynasty, or, say, 3900 B. C. This is the earliest representation of glass yet discovered.

*g* See *Origin of Nations*, p. 56. For further account of glass and glass-making in ancient Egypt, see Wilkinson's *Manners and Customs of the Ancient Egyptians*, vol. iii, p. 58, and Rawlinson's *Herodotus*, 2d ed., vol. ii, p. 292. Pellatt, in his *Curiosities of Glass-making*, gives beautifully colored lithographs of some of the glass found in Theban tombs. See also *Glass in the Old World*, London, 1882.

*h* The enumeration of articles put into the west pyramid mention "glass which might be bended and not broken".

*i* The tomb is supposed to be of the time of Osirtasan I, some 2500 to 3000 B. C. A late number of the *Saturday Review*, discussing the antiquity of glass, says of the Beni-Hassan inscription: "A much older picture, which probably represented the same manufacture, is among the half-obliterated scenes in a chamber of a tomb of Tih, at Sakkara, and dates from the time of the fifth dynasty, a time so remote that it is not possible, in spite of the assiduous researches of many Egyptologists, to give it a date in years."

Egyptian tribute. Coins and tokens of as late a date as the eleventh century are in the Museum of Paris, and a basin of the same century, and lamps of the fourteenth, all the products of Egyptian glass houses, are still in existence. This long-continued practice of the art of glass-making in Egypt was probably due to the possession by the Egyptians of a great abundance of the essential materials, sand and soda, the latter, which was of excellent quality, being found native on the shores of its lakes. In a valley abounding in these lakes extending northwest from Memphis the Egyptian expedition of Napoleon I found remains of ancient glass furnaces. In this locality, at the "very gates of the lakes of Nitre", the priests of P'tah or Vulcan, who were constantly engaged in experimenting, placed their glass factories, and Rawlinson states that their ruins may still be found. These glass works, however, were not confined to this valley, but were situated also in the Delta and along the Nile valley. Those of Alexandria, however, were the most famous, especially for the production of colored hollow glass and mosaics.

PROCESSES OF EGYPTIAN GLASS HOUSES AND CHARACTER OF THE GLASS.—The processes used by these early glass-makers were, in many respects, similar to those of the present day. The "batch" was melted in crucibles, and the glass-blower's tool pictured on the Beni-Hassan tomb might well be taken as a representative of those in use at Pittsburgh to-day. Cast glass appears to have been a common product both of the Egyptian and the Phœnician glass houses, and molds were also used both for blowing and for pressing. Some of the hollow ware gives evidence of having been made on wire molds, and other specimens indicate that the glass was molded around a core or "former" of sand. Pressed glass, however, was not made as American pressed glass is formed, a die being used, into which the glass was pressed, or the die was pressed into a mass of pasty glass. The perfection to which these processes were carried, however, will not compare with that attained to-day. Egypt in the days of its best glass-making could not produce a cast plate approaching in size, purity of the glass, or brilliancy of surface those of Saint-Gobain, nor would her blown and pressed ware approach that of the United States; but it must be conceded, that some of the specimens of ancient glass that have been preserved, (*a*) especially such as are evidently the result of careful, patient manipulation, are unsurpassed by the products of our modern glass-houses, as they not only display a high degree of art, but give such evidence of exquisite skill and a knowledge of the most refined and delicate processes that even now they excite unbounded admiration. Among these products may be mentioned embossed and molded reticulated vases, glass mosaics, imitation pearls, glass pastes in several colors, precious stones, glass eyes, the "ut'a" of mummies, bottles, etc. This perfection, however, is only seen in articles of luxury, and indicates a degree of skill on the part of the workman that justly entitles him to the title of an artist in the highest sense of the word, and the product to be termed a work of art. While all this may be said of the skill displayed in working the glass when made, the "metal", as glass itself is technically termed, was decidedly inferior to that of the present day. White glass, as we understand whiteness, was unknown, and the clear, white, brilliant flint-glass of our works of to-day would have excited astonishment in the Egyptian and Phœnician glass houses. Most of the specimens that have come down to us from these ancient glass works are articles of luxury, and therefore might give rise to the belief that most ancient glass was of this character; but such is not the fact. Glass of an inferior quality, for common use, was largely produced, and it is probable that it was much more extensively employed by the ancients than it is in our time. (*b*) They had no porcelain, and were forced to use metal vessels or those of glass for many of the uses for which porcelain is now employed.

COMPOSITION OF EGYPTIAN GLASS.—The early Egyptian, as well as other early glasses, appears from its analysis to be a soda-lime glass, the Egyptian containing from 70 to 72 per cent. of silica, 17 to 20 per cent. of soda, and 5 to 8½ per cent. of lime, with some iron and alumina. Its composition is very similar to plate-glass made without potash, containing, however, more impurities.

PHŒNICIAN GLASS.—Second to Egypt in the antiquity, extent, and character of its manufactures of glass, if indeed it did not for a time surpass it in the excellence of its products, was Phœnicia, that wonderful country which gave us letters, and whose nautical skill and commercial enterprise made the Mediterranean, even in Homer's time, a "Phœnician lake". The renown of the workmen of Phœnicia at an early date is evidenced in the selection of Hiram of Tyre, the artificer, whom Hiram the king loaned to Solomon for the ornamentation of the Temple. Both Tyre and Sidon were famous for their glass, and the beautiful hollow ware made by them was universally celebrated in the ancient world. As already noted, the river Belus, which was near the northern boundary of Phœnicia, furnished a sand of excellent quality, which added largely to the renown of Phœnician glass. Mr. Nesbitt (*c*) thinks that among the earliest products of Phœnicia in the art of glass-making are the colored beads of opaque glass in great variety of color and pattern, called by the Ashantees "Aggry" beads. These beads have been found in all parts of Europe, in India, and in many parts of Asia and Africa, (*d*) their wide dispersion, as well as the abundance of other forms of glass that are probably of Phœnician origin, bearing evidence to the extent of this industry,

*a* These are chiefly articles of luxury or personal ornament, and have been largely preserved through the custom of burying with the dead articles which the deceased regarded highly, or which were used constantly.

*b* See Winckelman's *Origin de l'art*.

*c* *South Kensington Museum of Art Hand-books: Glass*, by Alex. Nesbitt, F. S. A., page 13.

*d* These are the "Glain neidr" (adders' eggs) and the "Gleini na Droedh" (Druids' beads) of Wales and Ireland, which are regarded with superstitious veneration by the peasantry.

and there is good reason to think that many of the glass vases found in tombs in the countries washed by the Mediterranean are the products of Phœnician work-shops, rather than of those of the country in which they are found.

**CHARACTER OF PHŒNICIAN GLASS AND PROCESSES EMPLOYED.**—Speaking of the character of Phœnician glass and the processes known and practiced, Kenrick says:

They knew the effect of an addition of manganese to the frit of sand and soda in making glass clearer. They used the blow-pipe, the lathe, and the graver, and cast mirrors of glass. They must also have been acquainted with the art of imitating precious stones and coloring glass by means of metallic oxides. The "pillar of emerald" which Herodotus speaks of (ii, 44) in the Temple of Hercules at Tyre, "shining brightly in the night," can hardly have been anything else than a hollow cylinder of green glass, in which, as at Gades, a lamp burnt perpetually. (a)

Rawlinson says regarding Phœnician glass-makers:

What was the amount of excellence which they attained is uncertain; but the fame of the Sidonian glass in early times would seem to imply that they surpassed the artists both of Assyria and Egypt. (b)

**LATE PHŒNICIAN GLASS MANUFACTURE.**—As in Egypt, the manufacture of glass was continued in Phœnicia, especially at Sidon, far into the Christian era, even as late as the twelfth century, at which time it appears to have retained some of its ancient reputation. The art also seems to have found a place in the industries of the other Syrian cities. In the twelfth century some Jews of Antioch were known as glass-makers. In the fourteenth century Damascus was the chief seat of glass-making in the East, and as late as the seventeenth century glass-making is mentioned among the industries of Smyrna.

**GLASS-MAKING IN THE OTHER ANCIENT MONARCHIES.**—In following the history of glass-making, there is little to note after leaving the glass houses of Egypt and Phœnicia until we reach those of Rome. The other great monarchies do not appear to have become celebrated in this art, as the specimens found in their buried cities do not furnish sufficient data to enable the formation of any judgment as to the extent to which glass-making was practiced, and but little as to the character of the glass.

**ASSYRIAN GLASS.**—Layard found in the ruins of Nineveh, which was destroyed 625 B. C., a number of specimens of glass, among which were a glass lens and a small vase or bowl of a transparent green glass with the name and title of the Assyrian monarch Sargon (719 or 722 B. C.) This was blown in one piece, and was then shaped or hollowed by a turning machine, and is regarded as the earliest specimen of transparent glass. An earlier vase, with the name of a Khorsabad king, which Layard found, was stolen or lost. Many glass vases and bottles of elegant shape were unearthed in the same mound, some of which were colored, some ribbed, and others otherwise ornamented. In the palace of Babylon, at Kars, vases and bottles of gilt glass of Assyrian origin have lately been discovered, and M. Botta found among the ruins of Nineveh a round glass bottle or vial with oblong black spots melted into the glass, the earliest specimen of the tear-sown bottles known, the "*gafres de Venise*". The discoveries at Babylon, while they show the use of glass by its inhabitants, indicate the possession of but little skill, the vessels found being of small size, and the bottles very frequently misshapen. Egypt, however, exported immense quantities of small glass articles to Babylon, and some of the glass found may have been of Egyptian origin.

**GREEK GLASS.**—But little is known of the history of glass in Greece. Homer does not mention it, Aristophanes being the earliest writer who refers to it, and the excavations by Dr. Schliemann throw but little light on the subject. At Mycenæ and Troy he found but few pieces of glass, and these only beads, disks, and pieces of vitreous paste. General De Cesnola brought to light at Dali, in the island of Cyprus, a remarkable collection of Greek glass, containing 1,700 pieces, some of which show great skill; but these are by no means of the earliest Greek period, and are placed by him at later than 100 B. C. Greek art, however, had considerable influence upon Roman glass. The Portland vase, for example, shows marks of Greek rather than of Roman art, though it is not certain that it is of Grecian workmanship. However, it is certain that some glass was made in Greece, and many of the lovely Greek vases of the tombs of the countries of the Mediterranean are undoubtedly of this kind of glass. The Greeks appear also to have used glass occasionally for purposes of architectural decoration during the best period of Grecian art, but not to the extent that it was afterward used at Rome.

**CARTHAGINIAN GLASS.**—There is some evidence that Carthage was the seat of glass-making. As is well known, this city was thoroughly Tyrian, and the relations between it and the mother city were very close. It is probable that most of the glass used in the African colony was procured in Phœnicia. At the same time M. Deville, whose contributions to the history of glass have been so valuable, found on a tomb at Lyons the name of "Jules Alexander Africanus, citizen of Carthage, artist in glass". If this artist was from old Carthage, he must have gone to Lyons at least as early as the sack of that city, 146 B. C. Mr. G. Rawlinson attributes to Carthage work-shops many of the glass objects found in the northwest of Africa. The only glass yet found in the ruins of Carthage was in the tomb of Thapsus, but the tomb is probably of the Roman-Carthage period.

**ETRUSCAN GLASS.**—But little is known of the state of the glass-makers' art in Italy prior to the Christian era; but there is evidence from Etruscan tombs that this people, who are noted for their massive engineering works, were acquainted with the use of glass, and some very fine specimens have been brought to light. These specimens, however, are believed not to be of Etruscan origin, and as yet no distinct evidence of glass manufacture among this people has been found.



INTRODUCTION OF GLASS-MAKING INTO ROME.—It is uncertain when glass-making began to be practiced in Rome. By some it is assigned to 536 B. C., but others place its introduction as late as the time of Cicero, 106 B. C., and state that the first works were near the Flaminian circus. This latter statement is probably not correct. Though Cicero is the first Latin author who refers to glass, it was not, however, until the days of imperial Rome that glass-making in that city attained any importance, either by reason of the character or the extent of its products. It is probable that a cheap glass had been made in Rome before the time of the Cæsars, but the Romans had been dependent upon Egypt for the bulk of their glass, and with the wealth and luxury of the empire came a demand that stimulated its manufacture and use to a degree of development that has, in some respects, never been excelled, and perhaps never equaled. The beginning of the better period of Roman glass dates probably from Augustus. The secrets of the Egyptian glass houses were secured by purchase or by threats, and the long fusion, remelting the frit, and the slow cooling, that had given much of its reputation to Egypt, became the property of Rome. With this knowledge came perfection, and gold and silver cups gave place to those of glass. Strabo says "that in Rome such improvement had been made in the coloring and process of working, especially in making glass of a crystalline appearance, that you might buy there a cup and dish for half an as". The degree of skill in manipulation shown by the Roman glass-makers, as well as the taste exhibited in designing, is evident, not only in the stories of the fabulous sums paid for samples of their work, but in the exquisite specimens of their skill that have been preserved, such as the Portland and the Auldjo vases and the Naples amphora. These are as beautiful objects of the glass-makers' art as have been produced in any age of the world, and though at some of the late expositions our modern glass-makers have shown most elegant work in similar style the work of the Romans has rarely been excelled. (a)

AMOUNT AND VARIETY OF THE PRODUCTION OF ROMAN GLASS HOUSES.—If these vases and other similar works show the skill attained and the elegance and variety of the products of the Roman glass houses, the prodigious quantity made is evidenced by the wonderful abundance of the fragments of glass found even now, not only in and around the ancient city, but in all parts of the world where the Roman legions penetrated. Nesbitt states that in the winter of 1858-'59, during a residence of four months at Rome, he saw in the hands of dealers fragments of at least 1,000 to 1,200 vessels of colored glass, for the most part the crop of that season's discoveries. (b)

The number of specimens of Roman glass that have been found in Germany, France, Spain, and especially in England, is very great, the museums of those countries abounding in examples, and even now in some of them it is no uncommon occurrence to bring to light glass of the Roman period. The use of glass in Rome was not only very extensive, but entered into use for some purposes to a much greater extent than in modern times. For domestic purposes, for architectural decoration, and for personal ornaments, it was used far more extensively than with us, and so common was its use, and so largely and cheaply was it produced, that, as stated by Strabo in the passage above quoted, a cup and a dish were sold for a coin worth a little less than a cent.

LATER GLASS-MAKING.—As stated, it is uncertain when the art was introduced into Rome. It was probably derived from Egypt, but it did not reach perfection until after the beginning of the Christian era. A company of glass-makers established themselves in the city in the reign of Tiberius, and were assigned a street near the Porta Capena. In the succeeding reigns marked improvement was made, and in A. D. 220 glass-making had become of so much importance that Alexander Severus levied a tax upon its manufacture in common with other industries, which lasted until the time of Aurelian, if not later. Pellatt thinks that this tax was one of the causes of the transfer of the art to Venice, (c) but the transfer is more correctly ascribed to the incursions of the barbarians, and the dispersion of glass-makers attendant upon them.

BYZANTINE GLASS.—With the decline and fall of the city of Rome under the torrent of the German and Hunnish hordes the manufactories fell into comparative neglect and were confined to articles of every-day use. When Constantine the Great, about A. D. 330, made Byzantium his capital, he attracted to the city, with other tradesmen, the glass-makers of the world. In the first half of the fifth century the Emperor Theodosius exempted the glass-makers from all taxation. In the commencement of the eighth century Justinian II furnished the Caliph Walid with glass mosaics for a new mosque at Damascus, and in the middle of the tenth century Romanus II sent presents of glass to Cordova; indeed, so extensive was its manufacture at Byzantium that one of the gates leading to the port took its name from the adjacent quarter in which the glass houses were situated. As has been noted, many of the Byzantine artisans came originally from Rome, and brought with them the traditions and customs of the art as it had been practiced there. These, as was customary in this early period, were handed down from father to son. In the new Rome of the East glass-making for a while assumed a front rank among the arts, but from the specimens that have come to us it is evident the skill and splendor of the Roman period was not reached, though for five hundred years at least Byzantium secured and held the markets of the world. This art, with others, however, fell under the adverse influence of the bigoted emperors of the East, and the ancient

a The reproductions of the Portland vase in jasper ware by Wedgwood are well known, but its reproduction in glass by Mr. John Northwood, of Wordsley, England, is not so noted.

b *South Kensington Museum Art Hand-book: Glass*, by Alex. Nesbitt, F. S. A.; page 19. Those interested in the character of Roman glass and its manufacture will find in this work a very complete description.

c See *Curiosities of Glass-making*, page 8, note.



traditions were wholly lost. The glass that belongs probably to the later period shows but little of the elegance of form and the skill in manipulation of the early Byzantine and later Roman, and the weakness of the later days of the empire of the East had impressed itself upon its art, and with its fall its artisans were scattered, many seeking the shores of the Upper Adriatic to renew their art and restore some of its lost glory in the rising city of the refugees, Venice.

**EARLY GLASS-MAKING IN OTHER COUNTRIES.**—The details of the manufacture of glass in other countries prior to the Middle Ages are imperfectly known. Pliny states that the glass works of Gaul and Spain were established before those of Rome, and it may be possible that this is true, as in the days of the later republic and early empire Rome was too intent on extending its conquests to give that attention to the arts, other than those connected with war, which it afterward bestowed upon them. Wherever the Romans extended their conquests, however, in the western part of Europe, glass is found to a considerable extent in the ruins of their occupation.

**GLASS IN FRANCE.**—M. Fillon considers that the manufacture of glass in France began at Poitiers (*a*) in the second century. (*b*) These factories were active in the Roman and Frankish periods, survived the Norman invasion, and were left a legacy to the gentleman workers of the Middle Ages. In many tombs of the Gallo-Roman period in the neighborhood of Poitiers large quantities of vases of varied form, and sometimes of delicate and careful workmanship, are found; but the amount found in these and other tombs of France can only be described as immense. Abbé Cochet states that 20,000 vases were found buried in the cemeteries at Terre-Nigre, Bordeaux, and in many of the tombs glass vials, children's glass toys, beads, twisted sticks, and tiny glass vases, some not exceeding half an inch high, were very common, all indicating the extensive scale upon which the industry was operated. In the Boulogne museum are preserved some curious barrel-shaped jars of a low-grade glass quite green in color, bearing the mark of the imperial factory at Frontincennes, at Forêt Eu, which is supposed to have been started in the second century, and was the school shop of all the Norman factories of later times. It is still a great factory, and must surely be about the oldest in the world.

It is impossible to give a suggestion even of the styles and character of early glass found in France. As Christianity advanced and spread over Gaul the character of the glass changed, and in this way its history can be, in a measure, traced. Its use for church purposes also became established, a pope in the year 197 having ordered that wine should not be consecrated, as heretofore, in a wooden, but in a glass vessel. Glass chalices were used in the fifth century, but at last glass became so common that it was not deemed costly enough to celebrate this mystery, and the church found it best to interdict its use, though glass vessels were still used as late as the tenth century.

M. Fillon says that the written documents connected with glass works begin in the ninth century. Normandy was the first country where special privileges were given to glass-workers, and in the tenth and eleventh centuries the first dukes of Normandy bestowed special glass-making privileges on four families attached to their persons, these families continuing the manufacture of glass and enjoyed their privileges up to the last century; and to this day descendants of one of these families, the Brussards, are to be found as glass-makers.

**SPAIN.**—If Pliny's statement quoted in connection with France be true, glass was made in Spain before it was in Rome. As to the localities of these early works, Mr. Nesbitt quotes Sinobas as authority that in the Ibero-Roman period "glass was made chiefly in the valleys which run from the Pyrenees to the coast of Catalonia near the Ebro, also in Valencia and Murcia. Ruins of furnaces still met with in these parts are small in diameter". It is believed that the manufacture continued to exist under the Gothic kings, though others are of the opinion that the art did not survive the invasion of the barbarians. There is evidence that in the seventh, tenth, twelfth, thirteenth, and fourteenth centuries glass was made in various parts of Spain. An edict of 1324 banishes all glass ovens from inside the city of Barcelona, and after this date large quantities of glass seem to have been manufactured in Spain, both for home use and exportation.

**GERMANY.**—In Germany also the influence of Rome on the early glass is marked, and it is probable that glass was made in the vicinity of Cologne, Treves, and other places near the Rhine during the Roman occupation, but many questions in connection therewith are as yet unsolved. As to the glass of later times there is similar uncertainty. The drinking glasses found in the Saxon graves of Germany are similar to those found in France and England, but it is undetermined whether these were made in the countries in which they were found, or are all the product of one of these countries, and if so, which one. It seems probable, however, that the art of glass-making was not wholly allowed to die out after the Roman dominion had passed away. The early glass of Germany was inferior in color and ornamentation to that of its more southern and artistic rivals, but it was superior to them in hardness. The first notice of glass-making in Germany in any document yet published is that to the Bishop of Mainz, elsewhere referred to, in which the Abbot of Wearmouth, England, wrote about the middle of the eighth century, asking him to send him workmen who "can make vessels of glass well". Window-glass was also made in Germany at a very early period, and mirrors were made as early as the twelfth century. The use of the tin amalgam is claimed as a German invention of the fourteenth century, and German authors claim the invention of painted glass for their workmen.

*a* See *Glass in the Old World* (page 126), to which I am indebted for much of the information about early French glass.

*b* This can hardly be so if Pliny's statement is true.

BRITISH ISLANDS.—Though the evidence seems to indicate that glass was made in England by the Romans, it is not as yet quite fully determined that such was the fact. Beads and glass vessels of various kinds are found in tombs of the Roman period, and fragments of ornamented glass, and even of window-glass, are often met with in the ruins of towns and villas; but the similarity in most instances of these to Roman glass lead to the belief that they were imported. The probabilities are that, if glass was made in England by the Romans, it was of the coarser kind, the finer articles being the product of other countries. The remains of a glass furnace found at Buckholt in 1860, however, if it was of Roman origin, which is doubtful, would prove that colored and ornamented glass was made in England in the days of the Roman occupancy. It is worthy of note that some authors claim that glass was made in Britain in pre-Roman times; but if it was, it must have been of the coarsest and most common kinds. In Kentish graves, dating from about the time of the conversion of the Saxons to Christianity, many vessels of glass, mostly the peculiar elongated tumblers, are found, which Nesbitt thinks there is some reason to believe were made in England, though they resemble greatly French and German drinking vessels. At what time the manufacture of glass became firmly established in Britain is not known. In A. D. 670 an attempt was made to establish a glass factory at Newcastle-on-Tyne, but it was a failure, and eight hundred years passed before the attempt was renewed but in A. D. 675, when Benedict made glass for his monastery at Wearmouth, he imported workmen from France, who were probably skilled in making cast, not blown, glass for the windows, and eighty years later the Abbot of Wearmouth asked the Bishop of Mainz, in Germany, to send him a maker of glass vessels. For some centuries from this glass-making seemed to languish in England.

Little ancient glass is found in Scotland. Rome had but little foothold on its shores, and but few fragments of Roman glass have been found. Even the Druids left but few of their paste beads to be preserved in tombs. No record of glass-making in this country exists until 1620.

In Ireland there are more evidences of early glass-making than in Scotland. The art seems to have been practiced at an early period, and mosaic glass dating as early as 1112 exists. Some chalices are also in the museum of the Irish Academy that are supposed to date from the ninth and tenth centuries.

PERSIA, that ruled Egypt so long, carried away captive its most skilled workmen and artists and employed them in building and decorating their famous cities, Persepolis and Susa, and among the ruins of these cities to this day are found fragments of mosaics and other glass, evidently the work of these Egyptian captives. At least 400 B. C. the Persians made glass, as the Athenian ambassadors to Ecbatana drank "wine out of glass and golden cups", and the remarkable cup of Chosroes I (A. D. 532) proves that the art was practiced long into the Christian era; and even to the present glass works are in operation.

CHINA.—The same mistiness that surrounds everything in connection with the arts of this mysterious empire attaches to glass-making. There seems some reason to believe that glass was made in this country before the Christian era, though it does not appear to have attained much importance. The ancient books state that mirrors were made from pebbles and materials obtained from the sea and reduced to ashes, which is a fair description of glass-making. A factory still in existence in Shan-tung is believed to date as far back as the third century.

INDIA.—There are few traces of the manufacture of glass in India. The remark of Pliny that Indian glass was the finest, being made from crystal, is now believed to refer to Chinese glass, as no examples of early glass of undoubtedly Indian origin have yet been found.

## CHAPTER X.—MODERN GLASS.

MODERN GLASS-MAKING DATES FROM VENICE.—We have dated the history of glass-making from the workshops of Venice and its island of Murano. It was in the glass-houses of that "gentile island", (a) as Howell terms it, that the art that produced the beautiful and exquisite forms of Roman glass was revived, and from its "whole street of glass furnaces" came the knowledge and inspiration as well as many of the workmen who carried its manufacture into many of the countries of Europe, and laid in these countries the foundations of the glass industry that has continued until the present time.

Venetian glass did not, however, at once attain the full measure of its reputation. For many years after the establishment of the industry in that city Egyptian, Phœnician, Roman, and Byzantine glass were those of most repute in the markets of the world, while the earlier products of the Venetian glass houses were of a greatly different character from those that in the sixteenth century gave Venice such renown.

a See *Howell's Familiar Letters*. First letter dated Venice, May 20, 1621.

**INFLUENCE OF BARBARIANS UPON GLASS-MAKING.**—Glass-making, with all other arts, felt the influence of the barbarian deluge and that strange stupor that marks the centuries from the close of the fifth to the close of the eleventh. The demand for glass for other than the most common uses quite ceased when the barbarians conquered Rome and appropriated its wealth. The glass works of the imperial city were broken up and the workmen, for the most part, slain or scattered, while those that continued the art, from lack of opportunity, soon lost their cunning. Only in one branch did any of the former glory remain: the manufacture of mosaics and painted glass for windows. Here, as in so many of the arts, the church saved glass-making from perishing from the earth.

**REVIVAL OF ART INFLUENCED GLASS-MAKING.**—Such was the condition of glass manufacture when the works of Venice began to assume importance; but as the eleventh century drew to a close the great cities of Germany and Italy, with their opportunities for commerce and the arts, arose, and among them the republic city of Venice, and the artisans in glass of reputation were attracted to this rising city and shared in the great art revival of the Italian Renaissance. The false and debasing canons of the art of the dark ages were cast aside, and from the study of the pure and simple antique came those great works in modern glass that are regarded as masterpieces in form and color.

**EARLY VENETIAN GLASS-MAKING.**—It is not known when glass began to be manufactured in Venice. The Venetians place the date as early as the fifth century, but there is no evidence of its existence earlier than the eleventh, with the exception of certain mosaics that may be of Byzantine origin. In the thirteenth century the art had grown to considerable magnitude, and about the middle of this century codes of rules for regulating glass-workers were drawn up. In 1291 the Council of Ten, to guard against fire, ordered that the glass furnaces in the city should be demolished, but that they must be reconstructed in the district of Venice. This led to the establishment of works at Murano. This edict was afterward modified so as to allow the manufactories of small wares to remain, provided there were fifteen paces left between the works. In 1275 the council prohibited the exportation of glass-making material, and in 1295 renewed it; in addition, it levied a heavy fine upon all glass-makers who should leave Venice to practice their art in other cities, and in 1474 death was made the penalty. At this time the fame of Venetian glass had become so great that extraordinary efforts were made to induce workmen to leave Venice and establish its manufacture in other countries, and England, Spain, and Flanders all endeavored to secure workmen to build up their glass works. This was the occasion of the edicts of the great council to which we have referred. (a) In the sixteenth and seventeenth centuries glass-making reached its highest development in Venice, from which time it began to decline, and in the eighteenth century England, France, and Bohemia began to compete successfully with Murano, interrupting its trade, and the works became idle, the glory of Venetian glass departed, and only beads and common ware came from the shops that for five centuries had given an incontestable superiority to Murano. This lethargy remained until the art was recently revived through the efforts of Dr. Salvati.

**EXTENT OF THE INDUSTRY AT VENICE.**—The extent to which this art was practiced in Venice can be inferred from the fact that in the time of its prosperity 8,000 men were regularly employed, and the glass houses extended in an unbroken line for a mile along one of the streets of Murano. The manufacture was not carried on, as now, in large establishments, but by artisans working on a small scale, which may account for the great variety of form. For the most part, the glass, with the aid of the pincette, was shaped before the blow-pipe, and the forms of the product were vessels, window-glass and mosaics, optical glass, mirrors, and beads.

**CONDITION AND RESTRICTION OF WORKMEN.**—Mr. Jarves, in his admirable paper in *Harper's Magazine* on Venetian glass, in speaking of the causes that produced such a body of workmen and maintained the superiority of its glass through so many centuries, says:

As early as 1500 there were twenty-four glass houses at work at Murano, each having more or less its speciality. The furnaces in general were small. During the period of its greatest prosperity (the fifteenth, sixteenth, and seventeenth centuries) Murano counted 30,000 inhabitants, now reduced to about 5,000. Each owner of a factory was obliged to contribute annually a certain sum into a common fund for the succor of the unfortunate of their own class, poor and infirm artisans, or those out of employment, and for the maintenance of the schools of inventive design. No apprentice could be admitted as a master-workman before passing a strict examination in his art and proving his skill in the manufacture of certain objects. The candidate was elected into the body of masters by their secret ballots. Each factory was subject to inspection, night or day, by certain officers, whose duty was to see that the work was regular according to the statutes, to note the quantity and quality of the objects, and that no glass in fragments or cullet be exported. Proprietors and master-workmen of ten years' experience, if they honorably failed and had no other means of subsistence, were entitled to pensions of 70 ducats annually. When there were more master-workmen than could be profitably employed, it was forbidden to increase their number from the apprentices until there was a real call for new hands. Whoever became a member of the guild was obliged to take an oath of fidelity. No one who had not a regular discharge from his employer could be received into the service of another, and every proprietor was obliged to seal his cases with his own trade-mark. It was forbidden to employ strangers under any pretense. If there were not enough of the Muranese at times for labor, or to exercise the art, Venetians only might have the privilege, but they must be duly qualified. No employer could hire a master-workman who was in debt to another of the guild. Such were some of the regulations to keep the art in a high state of efficiency, and which for more than five centuries gave it an incontestable superiority in its special aim over other establishments in Europe. In fine, Murano became as artistically famous for its glass as Urbino, Pesaro, Gubbio, or Chaffagiola at the same time for majolica, but with far greater commercial development.

a It is impossible to follow the history of glass-making at Venice. An admirable account will be found in Nesbitt's "Glass" in the *South Kensington Art Hand-book*.

GLASS IN THE DARK AGES.—As has already been stated, the barbarian invasions and the destruction or decadence of the Roman power brought with it a decline in the art of making glass. The conquerors of Rome had but little in common with the taste and refinement that have sought and preserved as precious treasures the dainty and exquisite gems of the glass-maker's art of which so many evidences remain, and under their early dominion it seems probable that only the commoner and more useful forms of glass were produced. Thus it would appear that while glass-making in most of its higher and artistic processes was a lost art for some centuries, it was not wholly forgotten, but in all countries where Roman enterprise had established glass houses the art was preserved. It seems certain that France, Germany, Spain, and possibly England, made glass during the period of its decadence, and thus kept alive the practice of the art that was afterward, under the influence and example of Venice and by the art of its workmen, to grow in most of these countries into the glass works of to-day.

FRANCE.—It is reasonably certain that the manufacture of glass has not been wholly lost in France at any time since the days of Pliny and the Romans. The glass works at Poitiers, which were of so much importance, and which, if the evidence of the tombs in its neighborhood is to be taken, produced such enormous amounts of glass during the Roman period, seem to have maintained a continued existence and to have been of no little account even into the eighteenth century, when the industry declined under the competition of the glass houses of La Rochelle and Nantes. There is no doubt, however, that the works of Poitiers felt the same adverse influences as fell upon those of all Europe, and also that the new skill and the advance in its art that marked the close of the sixteenth century came from Venice. In 1572 one Salviati, "gentilhomme de Murano," came to Poitiers to practice his art, and was undoubtedly accompanied or followed by others. Their presence is evidenced in the efforts to produce fine and ornamented wares, and enameled glass, pretty drinking-cups, vases, and bottles, both white and colored, were some of the products of the period that followed the coming of these gentlemen of Murano. Glass-making, however, was by no means confined to the neighborhood of Poitiers, as works were erected at Provence as early as the thirteenth century, and attained considerable skill in the sixteenth. Large quantities of glass were made in Normandy in the twelfth century, and the le Valliant family, upon whose ancestors Charles VIII, in 1490, conferred the "privileges de verrerie", have continued its manufacture up to the present century. In the Boulogne museum are some barrel-shaped jars from the imperial factory of Frontincennes, which is supposed to date to the second century, and is still a great factory. In 1598 Henry IV permitted two "gentilshommes verriers", natives of Mantua, to establish themselves at Rouen, in order to make "verres de cristal, verres dorés, emailx, et autres ouvrages qui se font à Venise", and in 1603 the same king established works at Paris and Nevers. Colbert, the great finance minister of France, who did so much for French industry, wrote to his ambassador at Venice in 1664 requesting him to procure workmen for a glass house; but the story runs that the ambassador replied if he did so he ran the risk of being thrown into the sea. In 1665, however, eighteen Venetian glass-makers were obtained, and the manufacture of mirrors was begun at Paris. Colbert united this with another existing at Tour-la-ville, near Cherbourg, and in 1693 the united works were transferred to Saint-Gobain, where the manufacture is still carried on upon a very large scale. It was about this date also that Thevart rediscovered the method of casting plate-glass, and succeeded in making plates 84 by 50 inches.

For a time in the eighteenth century France seems to have lost the art of making "vases de verre", as in 1759 the Academy of Sciences offered a prize for the best essay on the means by which the art could be revived. If this was true, France has abundantly recovered its prestige, and Baccarat wares are to-day the rival of any. France seems also for a while to have been behind its neighbors in the manufacture of blown window-glass. Even in the beginning of the eighteenth century the French imported from Germany and Bohemia whatever window-glass of the better sort they used. In 1740 an association for the making of French cylindrical or broad window-glass was formed by Drolinvaux, workmen being drawn from Germany, and a manufactory was established at Lettenbach (Saint-Quirin), which attained good repute, and became later the parent factory of the modern French, Belgian, and some English plate-glass works.

A late German writer, from whom the above statement is derived, states also regarding the influence of Germany on French glass-making:

By holding closely together, and by steadily and firmly repelling French apprentices, the workmen who had been attracted from Germany kept off the competition of the natives of the country during a long time, and, as a consequence, even at the present day, among the French artisans in glass a very great majority bear German names, while German words and phrases are very numerous among the technical terms of the art.

The first lead-flint glass melted in France was by Lambert, at Saint-Cloud, in 1784. In 1790 the crystal manufactory of Muensthal, or Saint-Louis, was founded. In 1823 d'Artigues bought the glass manufactory of Saint-Anne, and changed it into the world-famous "Cristallerie de Baccarat".

SPAIN.—In this country, as in France and Germany, glass was made in the Roman period, and it is probable that its manufacture did not wholly cease in the dark ages, though this is not as well settled as in the case of France. Señor Juan F. Riano (I quote from Nesbitt), in the introduction to the catalogue of art objects of Spanish production in the South Kensington museum, has supplied much information with regard to the later history of Spanish glass-making. He commences the modern history of the art in Spain by stating that an Arab author of

the thirteenth century says that Mercia was renowned for the fabrication of glass and pottery, of both which materials large vases of the most exquisite and elegant shapes were made by the Moors; and that "Almeria was also famous for the fabrication of all sorts of vases and utensils, whether of iron, copper, or glass". The making of glass at Barcelona was probably of equal, if not of greater antiquity.

In a municipal edict of 1324 is a prohibition that the glass ovens should be inside the city. In 1455 permission was granted to the "vidrieros" to form a corporation under the patronage of Saint-Bernardino, and from this period some of the members figure as holding municipal charges. Jeronimo Paulo, who wrote in 1491 a description in Latin of the most remarkable things at Barcelona, says "they also send to Rome and other places many glass vessels of different sorts and kinds, which may well compete with those of Venice". Marineus Siculus, who writes at the beginning of the sixteenth century, says "that the best glass made in Spain is that of Barcelona"; and Gaspar Baneiros, in his *Chronographia*, published at Coimbra in 1562, mentions that excellent glass was made at Barcelona, almost equal to the Venetian. From the beginning of the seventeenth century there are several allusions to the merit of the Barcelona glass, and to the vast quantity which was exported.

Glass was also made at Cadalso, in the province of Toledo, as early as the beginning of the sixteenth century; other works were at Torre de Esteban, Hambroz, in 1680, which gave the most brilliant results, and at Recuenco, in the province of Cuenca, in the beginning of the sixteenth century, and in 1722; also in the seventeenth century at Valdemaquada, in the province of Avila. In a royal schedule, dated 1680, stating the prices at which things were to be sold in Madrid, glass made at Barcelona, Valdemaquada, and Villafranca in imitation of the Venetian is mentioned; and the glass of Valdemaquada was sold for a higher price than that made at the other places. There was also an important manufactory at La Granja, famous for fine chandeliers, mirrors, and engraved glass.

What we have of the products of these factories scarcely seems to support the assertion that the glass rivaled Venetian, though several pieces in the collection formed by Señor Riano closely resemble the products of Murano. One reason of the success of so many factories making glass of the same character as Venetian, and of the failures of England, was, no doubt, that the Spanish, in the interior of a country ill provided with the means for the transport of such an article, did not sustain so severe a competition as the English factories.

Spain is not a country very productive of fuel, and doubtless when the glass houses had burned up the wood in their neighborhood the manufacture ceased to be profitable. It would seem that, except near the coast, the glass must have been made with potash obtained from the lees of wine or from burnt wood, as the transport of soda, either from Egypt or from the coast, on which it could be produced from seaweed, would have been extremely costly. At Barcelona and other places on or near the coast soda may, of course, have been used.

GERMANY.—Though the specimens found in the neighborhood of Cologne, Treves, and other places bordering on or near the Rhine indicate that glass was made during the Roman occupation, it is not clear that it continued to be manufactured after this time. From the tenth to the fourteenth century, however, it is certain that window-glass was made in considerable quantities, and the letter of Outhbert, Abbot of Wearmouth, to Lullo, Bishop of Mainz, about the middle of the eighth century, would indicate that glass vessels were made as early as this. Vessels of the sixteenth century, however, are quite common, among them the "wiederkoms", some of which are twenty inches high, the oldest of which the date can be ascertained being 1553. From the wood-cuts in Agricola's *De Re Metallica*, published in 1556, we may gather some idea as to the products of German glass houses at that time, which seem to be vases, bottles, and retorts, but he does not indicate that any fine glassware was made in Germany. About the year 1600 glass was extensively made in Bohemia and other parts of Germany, and the fine crystal glass of Bohemia may date from this time. In 1609 glass-cutting was practiced, and some of the work in this century was said to be of remarkable fineness and delicacy. The invention of etching with fluoric acid is ascribed to Henry Schwanhard in 1670. The Electoral glass works, on the Isle of Peacocks, near Potsdam, was established in the eighteenth century, and, under Kunckel's management, gained great celebrity for its gold ruby. Then, under the ministry of Danckelmann, French workmen were drawn into the country, and under Moor's management the manufacture for blown plate-glass was established in 1695 at Neustadt-on-the-Dosse, whose workmen, when, after Danckelmann's overthrow, Neustadt for a time fell into stagnation, founded, at the instigation of the elector, Lothar Franz, the mirror manufacture at Lohr-on-the-Mayn, which in course of time attained to great distinction. Similar manufactures were soon afterward established at Schleibach, near Wurtzburg; at Falrafeld, near Vienna; at Gruenplan, near Hanoverian Minden; at Senftenberg, in the electorate of Saxony; and at Alten-Kronau, in Hesse. Finally, in 1710, through the influence of Count Rechtskron, mirror or plate-glass casting was introduced from France, and a mirror foundry was established after the model of Saint-Gobain at Neuhaus with French workmen, which, though protected in every way and defended by prohibitive regulations, in 1728 passed over to the Austrian state. In fact, plate-glass casting did not prosper in the beginning any better in Germany than in France. As little successful, too, were the attempts in various places made to obtain useful flint-glass for optical purposes, and it was not until 1806 that Utzschneider, at Benedictbeuren, produced such an article of the kind as answered the ends for which it was required.

BOHEMIA.—It was in Bohemia that Venetian glass first found a successful rival, this rivalry being at first manifest in the quality of the glass itself. Venetian glass had never been noted for the purity of the metal, and



with their purer materials the Bohemians were able to produce a much whiter glass than the Venetians could with their somewhat impure sand and soda from seaweed. The Bohemian crystal, therefore, soon became noted, and for centuries was held in high estimation, and only lost its pre-eminence with the invention of English flint. But it was not alone in the purity of its glass that Bohemia became the successful rival of Venice, for in the beginning of the seventeenth century the decoration of glass by engraving, probably a Bohemian invention, which soon became the fashion, sadly interfered with the products of the Italian city. The cut-glass was especially noted, and so sharp and injurious did the competition become that one Briati, a glass-maker of Murano, determined to go to Bohemia and learn the secret, and accordingly worked for three years in a Bohemian glass house as a porter, returning to Venice in 1739 to obtain a patent for ten years for the production of glass after the fashion of Bohemia. The excellent character of Bohemian glass is noticeable to this day, and the skill of the workmen who robbed Venice of its glory has not departed from the forests of Bohemia.

**THE LOW COUNTRIES.**—But little is known of the glass industry in the Low Countries until a very recent period, though it is positive that glass was made in Flanders as early as the fourteenth century. "Crystal of Antwerp" is mentioned in 1509, and in 1563 glass is mentioned as among the articles of export from Antwerp to England. In the first half of the seventeenth century several Muranese glass-workers obtained privileges for making glass, and in 1642 John Savonetti was permitted to establish glass-making at Brussels with an absolute prohibition of all imports. In the sixteenth or beginning of the seventeenth century were produced the glasses on which are to be seen the paintings of John Steen, Zerburch, and others. In comparatively modern times the works of Belgium have been quite noted, at one time the product of vases and such ware surpassing the French. It is stated that the celebrated Baccarat works were established by Belgian workmen.

**BRITISH ISLANDS.**—As has already been noted, there is considerable doubt as to the continued existence of the English glass works after the period of Roman occupancy, and it was not until the beginning of the fifteenth century that they awoke from their period of actual or comparative idleness. In 1447 John Prudde, of Westminster, covenanted to "use no glasse of England" in executing the windows of the Beauchamp chapel at Warwick, which would indicate that glass was made in England at that time. The vast palace of Henry VIII that formed one of the attractions of the Field of the Cloth of Gold in 1520 was built of wood and glass. The glass-maker's art, however, did not advance rapidly, for, in 1557, according to quaint Thomas Charnock:

As for glass-makers, they be scant in the land;  
Yet one there is, as I do understand,  
And in Sussex is now his habitation;  
At Chiddingsfold he works of his occupation.

In 1589 George Longe petitioned for a patent, in which he stated that there were fifteen glass houses in England. These he proposed to reduce to two and rebuild the balance in Ireland, whereby the wood of England would be saved and that of Ireland wasted. In the reign of Queen Elizabeth some persecuted Protestants from France came to Newcastle and worked at their trade of glass-making at the Close Gate, and afterward went to Tyne. In 1662, Fuller states that "coarse glass-making was, in this county (Sussex), of great antiquity", and another, writing of the manufacture of glass in that county, says:

Neither can we match the purity of Venice, and yet many green ones are blown in Sussex profitable to the makers and convenient to the users thereof.

**INFLUENCE OF VENICE ON ENGLAND.**—As the use of glass began to increase in England adventurers from Venice and other portions of the continent sought to advance their fortunes by bringing schemes for making glass of superior quality before the English government. In 1550 eight Muranese glass-makers, imprisoned in London, who had been induced to go there by offers of no small sums of money, and who had heard of the edicts of the Council of Ten, petitioned the council to be allowed to work out the money received. On June 13, 1550, the council, to gratify the king, decided to allow this. For the next few years evidences of the influence of Venetian workmen multiply, and the art began to assume importance. Early in the seventeenth century sea-coal began to be used. Mansel secured the patents for its use in 1616, and set to work making both window-glass and glass vessels of various kinds, having brought a Venetian to aid him. About this time one of the most important advances or discoveries in modern glass-making, and one of the very few real discoveries of modern time, was achieved (the manufacture of lead flint), and the English workman had this beautiful and brilliant glass to stimulate his exertions. In 1677 the Duke of Buckingham made at Lambeth "huge vases", "clear, ponderous, and thick as crystal," as well as looking-glass plates and windows for coaches. In 1673, at the "Italian glass house at Greenwich", "glass was blown of finer metal than that of Murano at Venice." The revocation of the edict at Nantes in 1685 drew a number of glass-workers to England, and the manufacture continued to improve, until, in 1736, Dr. Pococke considered English glass to be superior to that of Bohemia, and only inferior to that of the royal Prussian glass houses. From this time the manufacture of glass was of growing importance, and the details need not be given.

**RUSSIA.**—In Russia the glass industry first obtained a firm footing in the course of the seventeenth and eighteenth centuries, having been introduced by German and Bohemian workmen. As regards the details of its



introduction and establishment, slight information has ever reached the public. We have historical mention of a glass manufactory at Schabino, near Jamburg, in 1717, and in 1720 an establishment for the making of French mirrors and dishes and plates of crystal was opened at Kiew. In the last year of the last century we find mention of Lund's plate-glass manufactory at Wyborg, in Finland, and of Bolew's similar establishment in the Russian government (province) of Rajasan. At the same time the imperial mirror foundery at Saint Petersburg had already begun work; and the imperial crystal and hollow-glass manufactory, which exists at the present day, had been already established at the same place. In 1792, with the aid of workmen from Gruenenplan, the foundation was laid of the Amelung mirror manufactory at Dorpat, near which place, in 1780, a similar establishment had been set up by Major Lauw, but its existence had been brief.

## CHAPTER XI.—THE PRESENT CONDITION OF GLASS-MAKING IN EUROPE.

**CHIEF GLASS-MAKING COUNTRIES OF EUROPE.**—The countries of Europe most largely engaged in the manufacture of glass at the present time are England, France, Belgium, Germany, and Austria-Hungary. Each of these countries not only manufacture most of the kinds of glass needed for its own use, but the factories supply the non-glass-making countries of the world and supplement the production of each other and of such other states as manufacture to some extent. This is especially true of the finer grades of glassware (table and ornamental glass) and plate-glass.

**EACH COUNTRY HAS A SPECIALTY.**—While each of the countries named produces most, if not all, of the chief varieties of glass, each one has become especially skillful in the manufacture of some particular variety, and has secured and maintained a pre-eminence in its production that has enabled it to command the markets of the world.

**ENGLAND'S SPECIALTIES.**—England is especially noted for the beauty, purity, and brilliancy of her flint ware, which is without doubt the purest and most brilliant made. Individual glass houses in other countries may produce flint that may be compared with some English flint, but none, as a commercial product, that can rival it, while in no other country does the bulk of the flint-glass made approach even the bulk of that made in England. These remarks apply to lead-flint only, as the American lime-flint is probably, so far as the metal is concerned, equal, if not superior, to any other. In the blowing, cutting, and engraving of the flint, the regularity and perfection of the work, as well as the beauty and brilliancy of the finished ware, England is unequalled. The exhibit of Thomas Webb & Sons at the Paris exposition of 1878 surpasses in these respects, and in the limpid whiteness, purity, and brilliancy of the metal, all other flint I have ever seen, and was justly entitled to the "grand prix" it received, while the vases engraved by Mr. Northwood in the style of the Portland vase equal in workmanship, if they do not surpass, that product of the glass-makers' and engravers' art. Certainly no modern work equals it.

**FRANCE'S SPECIALTIES.**—The artistic taste shown in the product of the French glass houses has given French glassware a world-wide reputation. The metal is not as white as that of Bohemia, nor has it the brilliancy and fire of the English flint; but for elegance of shape, lightness of design, and beauty of glass, all combined, it is unsurpassed. The products of the Baccarat works have been regarded for years as models of taste, and have been eagerly sought for and copied in cheaper wares by the glass houses of other countries. France is also unsurpassed in the manufacture of plate-glass, the product of the Saint-Gobain works being taken as the standard of color, quality, and perfection; and to say that the plate-glass of any works equals French plate is generally considered sufficient praise. (a) The same artistic taste that has given French glassware so enviable a reputation is displayed in the staining and decorating of window- and plate-glass. The stained-glass windows of French artists show remarkable ability in designing and execution. (b) The decoration of fancy ware by various methods, especially by enameling and etching, is also carried to a high state of perfection, both as to color and workmanship.

**BELGIUM'S SPECIALTY.**—Belgium is pre-eminently the window-glass manufacturer of the world, and though the other countries mentioned above (England, France, Germany, and Austria-Hungary) all make window-glass to a considerable extent, there is not one of them in which Belgian window-glass does not find a market. A large amount, equaling a large proportion of their consumption, is also exported to other countries, and even the United States imported in the fiscal year ending June 30, 1880, 37,927,414 pounds of Belgian window-glass, valued at

<sup>a</sup> Our American works claim to have succeeded in making plate-glass fully equal to the French; indeed, some works claim to make better.

<sup>b</sup> Most marked advances in the art of staining windows have been made in the last ten years in this country, and the productions of Tiffany and La Farge rival those of the artists of any country.

\$1,230,622. The excellent quality of this glass, as well as its remarkably low price, accounts for this import. The average value of the Belgian window-glass imported into this country in 1880 was about  $3\frac{1}{4}$  cents per pound.

**GERMANY'S SPECIALTY.**—Germany is especially noted in the markets of the world for her silvered plate or looking-glass and for her cheap table ware and colored vases. The production of mirrors of various grades, largely of the cheaper kinds, in Germany is enormous, and their exportation constitute a large part of her foreign trade. Of the \$2,897,747 in value of silvered plate imported into the United States in 1880, \$2,746,636 was from Germany. The cheap colored-glass vases of this country were the first (about 1830) to supplant the decorated china vases, which until that time had undisputed sway as cheap mantel ornaments, and she still retains much of the trade in these articles, though other nations manufacture them in large quantities. Germany is also noted for a remarkable ruby glass, which was brought to perfection by Kunckel in 1679.

**AUSTRIA-HUNGARY'S SPECIALTIES.**—Austria, or Bohemia in Austria, rivals France in the graceful forms, the variety of shapes, and the beauty of the engraving and decoration of its glassware, and surpasses it in the color and purity of the glass itself. Bohemian glass has been renowned for many years, its workmen apparently inheriting the skill and some of the peculiar processes of manufacture of the Venetians when the cunning of glass-making left the city of the Doges, and it is this cunning in design and ornamentation that has given it its celebrity. It does not compare with the English flint in brilliancy, and is only equaled by the French in beauty of contour, but in purity, whiteness, and homogeneity of metal it is the best white glass made in Europe, while their success in making glass of intricate design and great difficulty of manipulation makes the Bohemian glass workers second only to those of Venice.

**VENETIAN GLASS.**—Though not a large producer of glass, Venice deserves most honorable mention in any statement of the specialties in glass manufacture of the different European nations, and the recent very successful revival of the manufacture of Venetian glass at Murano, that "gentle island which attends the cittie of Venice", promises to restore to that city the world-wide celebrity of its former days of glass-making. The wonderful color, intricacy of design, and execution of the mosaics; the pastes, gem-like in color and brilliancy; the murrhine of Pliny; the remarkable enameling of the famous tazze of St. Mark's; the aventurine or imitation gold-stone, with its difficulties in manufacture; vases in millefiori, others with metallic flakes and spun and twisted threads of filigree work; all of these products of the elder Venetian glass houses are reproduced with wonderful fidelity in the modern Venetian glass of the Venice and Murano Glass and Mosaic Company. The glass-bead manufacture of Venice is also a remarkable industry, 6,000,000 pounds a year being produced, the markets of the world being largely supplied from this country.

**GLASS IN OTHER EUROPEAN COUNTRIES.**—None of the other European countries are especially noted for their glass, nor is it made to any great extent in any of them. Sweden and Norway make glass of the commoner kinds, window, flint, and bottle, but no plate. Russia has largely increased its make of glass in the last ten years, but does not yet supply the demand of its own people even for the commoner kinds. Holland makes large quantities of a square black bottle. Of the glass works of Spain and Portugal but little is known.

**PLATE-GLASS FACTORIES IN EUROPE.**—The manufactories of plate-glass are located chiefly in England, France, Belgium, and Germany. (a) In England there are six or seven works, in France seven, in Belgium five, in Germany five, in Russia one, and in Austria-Hungary (Bohemia) one, possibly two, making a total of twenty-six or twenty-seven. These differ greatly as to production, most of the English, French, and Belgian works being very extensive, while most of those of Germany and of Russia and Bohemia are comparatively small. Some blown plate is made in Bohemia, Bavaria, and England, and patent plate in England.

**PRODUCTION OF PLATE-GLASS.**—Of these countries France is the largest producer of plate-glass, England the next, Belgium the third, and Germany the fourth. Mr. Charles Colné (b) estimated the production of Europe in 1877 at 1,800,000 square yards, or 16,200,000 square feet, valued at \$12,000,000. (c) This production he distributes as follows:

	Square feet.
France .....	5,400,000
England .....	5,400,000
Belgium .....	2,250,000
Other countries .....	3,150,000
Total .....	16,200,000

This production has largely increased since the date named. Mr. Charles Palmer, on behalf of the plate-glass manufacturers of England, made the accompanying statement regarding the weekly production of polished plate-glass in England, France, and Belgium (d) to the commissioner to negotiate a new commercial treaty with France.

a Statistics of the European glass houses are exceedingly difficult to obtain, especially in England. The statistics given will therefore be regarded only as an approximation unless otherwise stated.

b See Mr. Charles Colné's *Report on Glass and Glassware at the Paris Exposition of 1878*, page 329. Washington, 1881.

c Mr. Colné places the production of 1860 at 992,000 square yards, and of 1867 at 1,100,000 square yards.

d See *English Blue Book*, Commercial, No. 38, 1881, pp. 121, 122.

## PLATE-GLASS.

WORKS IN BELGIUM.		WORKS IN FRANCE.			
Companies.	Weekly production in English feet.	Companies.	Weekly production in English feet.	Total.	
Belgian Plate-Glass Syndicate:	<i>Feet.</i>		<i>Feet.</i>	<i>Feet.</i>	
Floreffe .....	25,000	Floreffe (Belgian company), at Jeumont, department du Nord..	32,000		
Sainte Marie d'Oignies .....	25,000	Sainte Marie d'Oignies (Belgian company), at Recquignies, department du Nord.	32,000		
Roux .....	15,000			64,000	
Courcelles .....	20,000	Saint-Gobain Company:			
Auvelais .....	10,000	Saint-Gobain, at Aisne .....	} 80,000		
	95,000	Chauny, at Aisne .....			
		Cirey, at Meurthe .....		50,000	
		Montluçon, at Allier .....		32,000	
		Aunche, department du Nord .....	16,000	178,000	
				242,000	
Quantity of polished plate-glass made in England .....				175,000	

Assuming that these works would average forty weeks' running in a year, and adding to the production of these countries thus found the best estimates obtainable for Germany, Russia, and Austria-Hungary, the production of Europe would be as follows:

	Square feet.
France .....	9,680,000
England .....	5,000,000
Belgium .....	3,800,000
Germany .....	2,900,000
Russia .....	250,000
Austria-Hungary .....	400,000
Total .....	22,030,000

This estimate agrees substantially with that of Mr. N. T. De Pauw, who estimates the production of Europe at 500,000 square feet a week. (a)

PRICES OF PLATE-GLASS IN EUROPE.—Mr. Palmer, in his statement to the French treaty commissioner before referred to, gives the following as the prices of plate-glass at the date of his communication:

LONDON.		PARIS.		
PRICE OF FRENCH POLISHED PLATE.		PRICE OF FRENCH POLISHED GLASS.		
Saint-Gobain, English tariff, less 40, 5, and 2½ per cent.		French tariff, less 50 per cent., discount 3 per cent., and 10 per cent. premium annually, and supplementary discount.		
Size.	Price per foot.	Size.	Supplementary discount.	Price per foot, net.
	<i>s. d.</i>			<i>s. d.</i>
About 10 feet superficial .....	1 6	10 feet superficial .....		1 11½
About 22 feet superficial .....	1 6½	22 feet superficial .....	Subject to 5 per cent. ....	2 0
About 33 feet superficial .....	1 6½	33 feet superficial .....	Subject to 10 per cent. ....	2 3½
About 45 feet superficial .....	1 7	45 feet superficial .....	Subject to 15 per cent. ....	2 8½
About 65 feet superficial .....	1 7½	65 feet superficial .....	Subject to 15 per cent. ....	2 7½

WINDOW-GLASS IN EUROPE.—It is impossible from the data at hand to even estimate the production of window-glass in Europe or the number of factories at work. No statistics, not even an estimate, has been obtained from England. In Belgium there are 61 window-glass factories, with 216 furnaces, of which but 138 were in operation recently. These works produce from 3,600,000 to 4,000,000 boxes of glass of 50 feet each annually. In France there are from 25 to 30 furnaces, producing from 800,000 to 900,000 boxes annually; and in Sweden, 4 factories, with an annual production of 40,000 boxes; in Norway, 1 factory, no product given; in Italy, 12 factories. In Austria-Hungary, 63 factories make window-glass; in Germany, 86, while from Switzerland, Spain, Portugal, and Russia I have no statistics, though window-glass is made in all of those countries.

**FLINT- AND BOTTLE-GLASS.**—The statistics of the manufacture of flint- and bottle-glass in Europe are even more meager than those of plate- and window-glass. All the information that has been obtained is included under the notes of the manufacture of each country which follow.

**MANUFACTURE OF GLASS IN GREAT BRITAIN.**—The glass manufacturers of Great Britain are, as a rule, extremely chary about giving statistical information concerning their works, and it is a question whether any late complete statement as to the number and production of their glass houses exists. A table published in the factory returns of 1871 shows the number, locality, and employés of the glass works of the United Kingdom at that time to be as follows:

Localities.	Number.	Children.	Males up to 18.	Males above 18.	Females.	Total.
Durham .....	24	10	1,113	2,153	401	3,677
Lancaster .....	37	6	1,530	3,602	927	6,065
Middlesex .....	16	4	134	319	30	487
Northumberland .....	9	7	117	277	23	424
Somerset .....	1	.....	70	243	6	319
Stafford .....	33	1	808	2,755	312	3,876
Surrey .....	9	.....	86	136	5	227
Warwick .....	47	3	274	874	167	1,318
Worcester .....	8	2	56	131	7	196
York .....	20	12	877	1,901	138	2,988
Scotland .....	19	1	464	1,037	91	1,593
Ireland .....	8	.....	63	192	9	264
Total .....	240	46	5,592	13,680	2,116	21,434

**CHIEF LOCALITIES.**—The chief locality for glass manufacture in Great Britain is in the north of England especially on the Tyne, plate, window, and flint, both blown and pressed, being made in large quantities. Plate is also made at Saint Helen's, in Lancashire, at and near Birmingham, and at London; flint in London, the Birmingham district, Warrington, etc.; window-glass very extensively in the Birmingham district, and bottles and window-glass near Liverpool.

**DECLINE OF THE ENGLISH GLASS INDUSTRY.**—If the statements that are constantly appearing in the English journals devoted to this industry are true, glass-making in Great Britain is not in a very prosperous condition. A correspondent of the *Pottery Gazette* says:

It is a very significant fact that nearly every trade in this country has made gigantic strides in advance during the past thirty-five years, during which time the glass trade has been stationary, if it has not even retrograded in its productiveness. (a)

This condition of affairs is especially noticeable in the flint-glass business. The same journal gave recently a list of 30 flint-glass furnaces, containing 296 pots, located in various parts of the United Kingdom, that had become extinct. Commenting upon this that paper says:

It is but just to say that some of these houses have removed to more convenient works, to the extent of about 6 or 8 furnaces and 48 or 60 pots; but still there is a great reduction in the number of works, during which period it must be borne in mind the population has nearly doubled.

The following table shows the value of the British imports and exports of glass for the years 1878, 1879, and 1880:

#### IMPORTS OF GLASS.

	1878.	1879.	1880.
Window and German sheet, including shades and cylinders.....	£452,202	£450,647	£476,338
Flint.....	489,518	174,113	170,593
Plate, silvered or not.....	233,602	163,064	214,917
Manufactures, unenumerated, and old broken.....	879,733	789,066	906,991

#### EXPORTS OF GLASS.

	1878.	1879.	1880.
Plate.....	£106,762	£133,635	£192,607
Flint.....	280,747	230,587	248,604
Common bottles.....	310,307	305,606	332,888
Other manufactures, unenumerated.....	99,068	113,255	147,321
Glass of all kinds not of English manufacture.....	149,275	100,635	186,980

It will be noted that the imports of 1878 and 1880 do not differ much except as to flint, which shows a decided decrease, while the exports show in all classes of glass an increase. Part of the decline in flint-glass is no doubt

due to the competition of the cheaper lime-glass, which, for ordinary purposes, is fully as good, and is now made of a superior quality. At the same time it is true that for beauty and brilliancy no glass can compare with English lead-flint.

**MANUFACTURE OF GLASS IN FRANCE.**—For many years France, through the Saint-Gobain works, has virtually controlled the manufacture of plate-glass on the continent of Europe, and, to a large extent, its production and prices throughout the world. The Saint-Gobain Company not only own four of the seven French plate-glass works, producing fully 70 per cent. of the total make of France, but they also own the only two important plate-glass works of Germany. On the other hand, however, it is to be noted that two of the remaining three of the French plate-glass works are owned by a Belgian company. It thus appears that the plate-glass production of Europe is largely controlled by two companies, one French and the other Belgian. It is possible that the number of plate-glass works at present in France should be given as eight, as a factory was erected at Saint-Denis, near Paris, a few years since, though I am not advised whether it is running at present. The Saint-Gobain works have made the largest sheets of plate-glass that have ever been produced. At the exhibition of 1878 at Paris an unsilvered polished plate, measuring 21 feet 2 inches by 13 feet 6 inches, was exhibited. A special table had to be prepared on which to cast this enormous plate. The quality of the French plate is most excellent, and is the standard for comparison in all the countries of the world. A considerable amount of the production of this glass is used in the manufacture of mirrors, some 275,000 square yards being consumed annually in this way. The manufacture of window-glass in France is relatively of the least importance, the production of plate, flint (lime and lead), and of bottles being greater in value than that of window-glass. According to Mr. Colné, there were in France in 1878 (*a*) from 25 to 30 furnaces, with 8 pots each, producing from 40,000,000 to 45,000,000 square feet. These are found almost entirely in the north of France, near the coal-fields. Large quantities of round, oval, and square shades, for protecting clocks, artificial flowers, etc., are made in France, the process of manufacture being similar to that of window-glass, the sheets being blown in cylinders of a very even thickness all through. The coloring, staining, painting, and decorating of window-glass is carried on to a remarkable extent in that country, there being in the neighborhood of five hundred establishments in France for thus manipulating sheet-glass, and the French colored sheet-glass is especially notable both for its colors and for their manipulation. The so-called flashed or doubled glass is very common, both in sheet and flint, flint glassware being in some instances coated with as many as four different layers of different colored glass put on very thin and evenly. Most of the stained or colored glass used comes from the departments of the Nord and Pas-de-Calais. The work at many of the establishments has attained a high degree of perfection, and the French stained glass, by reason of its artistic excellence and cheapness, is in demand in all parts of the world. As has already been stated, the French glass houses are especially noted for the taste displayed in their flint ware, both lime and lead; but the quality is not as good as the English, though a marked improvement has recently been made in this respect, and the gracefulness of the forms and the beauty of the designs have given French crystal glass a reputation that is unrivaled. The decoration of window-glass with enamel colors in imitation of the antique is also quite an industry in France. Most of the work in the French flint houses is hand-work, the result depending largely upon the manual dexterity of the workman. Pressing on the American system is not employed to any great extent, while that which is made is decidedly inferior to the American.

Owing to her wine production, France is naturally a large manufacturer of bottles, producing annually from 125,000,000 to 150,000,000; indeed, the value of bottles made in this country exceeds that of any other form of glass. Some of the bottle works have been established for a long time, one, that of J. Tumbenif Neveu et Neveu, in the Jura, being founded in 1506. It was at this place in 1630 that the first gentlemen glass-blowers (*gentilhommes verriers*) were made by decree of the king.

The following table published in the *Report on Glass and Glassware of the Paris Exposition* shows approximately the value of the annual production and exportation of glass of French manufacture in 1878:

Description.	Production.	Export.
Crystal .....	\$2,200,000	\$800,000
Glassware .....	2,800,000	1,600,000
Plate-glass .....	5,000,000	1,000,000
Window-glass .....	3,000,000	600,000
Bottles.....	8,000,000	2,400,000

**MANUFACTURE OF GLASS IN BELGIUM.**—Belgium possesses excellent facilities for the manufacture of glass, and in some lines, especially window-glass, these facilities have enabled her to produce so cheaply as to command a portion of the trade of the most important countries of the world. Fully two-thirds of the glass made in Belgium is exported. As is noted elsewhere, Belgium has five plate-glass factories, producing about 94,000 square feet polished plate a year. While some of the plate in Belgium equals the French, this is not true of all manufactured. The production, however, is increasing, and the quality is improving every year. This

*a Report of Paris Exposition on Glass and Glassware, Charles Colné, page 245. Washington, 1881.*

production is controlled by a syndicate, as is also the production of plate-glass in France. There are in Belgium 61 window-glass factories, with 216 furnaces, containing from 6 to 8 pots each, of which at a recent date 78 were idle, leaving but 138 in operation. These works are mostly situated in Charleroi. Most of the furnaces used are gas furnaces. These works produce from 180,000,000 to 200,000,000 square feet annually, or, say, from 3,600,000 to 4,000,000 boxes of fifty feet each. The Belgian window-glass is, as a rule, of a very good quality, free from bubbles or impurities, of a good color, and even surface. A large quantity of the colored glass is of a superior quality and very clear color. Their flashed glass is very good, and is admirably adapted for etching or engraving. They also make quantities of corrugated, depolished, and painted sheets. Some corrugated cylinders 7½ feet high have been made at Charleroy. Depolishing is done by the Tilghman sand-blast. Considerable glassware, both lead and flint, is made in Belgium, but it is not, as a rule, of a high standard of excellence, though the product of some of the works, especially that of Val Saint Lambert, is fully equal to the English and the French. The cheapness of this ware has made a great demand for it, especially when made into objects of utility. The exportation of this grade of glass amounts to one and a half million to two million dollars annually. The bottle industry of Belgium does not hold the same relative rank as this industry does in either Germany or France, and the production from 1875 to 1880 was only about 12,000,000 annually, not as many as the single works of Siemens at Dresden make. This industry has been much neglected in recent years. In 1872 12 furnaces were at work on bottles; in 1877 but 5. In 1872 Belgium exported 7,568,000 pounds of bottles, and imported only 1,377,000 pounds; in 1877, however, the exports amounted to only 1,775,000 pounds, and the importations had increased to 3,476,000 pounds.

MANUFACTURE OF GLASS IN GERMANY.—In 1882 there were in Germany 317 establishments for the manufacture of glass, (a) a reduction from 329 in 1878, (b) and 348 in 1873. (c) Many of these, however, were of little importance, being either small works for the production of watch crystals, blown pearls, etc., or so-called "refineries" similar to those common in Bohemia, in which crude glass is produced, to be finished in other works. (d) These glass works are found in nearly all parts of the empire, being most numerous in Prussia, especially in Silesia. The production of the different kinds of glass, however, is not so widely distributed, certain districts being the centers of production of certain kinds. In Thuringia and the Bavarian forests large quantities of both blown and cast glass are made for the mirror works at Fürt h. (e) Window-glass is made chiefly in the Rhine provinces, Silesia, and Westphalia; common table ware in the Rhine provinces and Lusatia; fine table ware in the forests of Bavaria and Lorraine; and chemical ware in the forests of Bavaria and Brandenburg. The glass works of Saxony make large quantities of lamp articles; and Saarbrück, Prussia, and Saxony produce bottles very extensively, one establishment, that of Fred. Siemens, at Dresden, producing 16,000,000 annually.

The statistics of the glass houses of Germany other than those given above are not only exceedingly meager, but very difficult of classification. The best information obtainable places the number of establishments at which plate-glass is made at five. Two of these, Stolberg and Mannheim, owned by the French company of Saint-Gobain, had for a long time the monopoly of the manufacture of plate-glass in Germany, but within a few years past at least three other works have been established. In Thuringia and the Bavarian forests, also, according to the *German Catalogue of the Centennial Exhibition*, glass is made by casting, the plates being ground by water-power with very primitive machinery. These plates are chiefly used at Fürt h for the manufacture of looking-glass. There are in the neighborhood of 86 establishments, with 125 furnaces, averaging 7 pots each, at which window-glass and blown spiegel-glass are made, and about the same number make bottles, carboys, and demijohns. At the other works, and also at some of those making window-glass and bottles, various kinds of table ware, articles of luxury, chemical apparatus, etc., are made.

FURNACES AND FUEL.—A great deal of attention has been paid in Germany to the construction and method of firing furnaces, and some very important advances have been made. Direct firing has been abandoned in many works and systems of indirect firing adopted. The Siemens furnace, not only with pots, but of the tank variety, has been very successful. Other systems, as the Nehse and the Boetius, are in use. While coal is the chief fuel of the glass houses, the use of wood, peat, and turf is by no means uncommon. When wood is used, the works are located with reference to its supply, and as the wood is exhausted and transportation into certain districts is made easier and cheaper these works are abandoned. The development of the glass industry of Germany is now in the neighborhood of the deposits of mineral coal, the old glass-making districts gradually losing their prominence.

MANUFACTURE OF GLASS IN AUSTRIA-HUNGARY.—The beauty, elegance, and perfection of the Austrian glassware, as well as the skill displayed in its manufacture, have given it a reputation that is second to none other. The Bohemian glassware is a lime glass, containing little or no lead but a large percentage of silica, and is consequently well adapted to decoration. The purity, whiteness, and homogeneity of the metal make it equal to the best white glass produced in Europe. Not only in form and metal does the Bohemian ware rank with the highest, but

a See *Deutschlands Glasindustrie*, Julius Fahdt. Dresden, 1882.

b See same for 1878.

c *Bulletin of the Society for the Encouragement of National Industry*, page 71. Paris, 1877.

d In 1873 it was stated that but 250 of the German glass houses were of much importance. It is true, however, that though, as stated, the number of works has declined, the output of many of them has largely increased.

e Very large quantities of little mirrors, called *Judenmasspiegel*, are made in Germany.



in its manipulation it has deservedly a great reputation, the variety and diversity, as well as the beauty, of its engraved and decorated articles, being beyond question. The conditions of manufacture of this Bohemian glass are also such that it can be very cheaply produced.

One of the specialties of Austrian glass-making is the manufacture of various fabrics for ladies' wear from spun glass. The glass is spun into threads, like ordinary silk or cotton, and woven into different-colored fabrics, sometimes entirely of glass and sometimes with a warp of silk or cotton. Collars, neckties, cords and tassels, fringes, pin-cushions, feathers, belts, etc., are all made of this material. At the Paris exposition in 1878 a bonnet made entirely of spun glass, with feather and ribbons lined with silk, was shown, as well as cloaks and other articles of wear. This spun glass is also used for watch-chains, brushes, etc. Glass flowers are also made to a considerable extent, but it is difficult for these to compete with those made from china. As is stated elsewhere, large quantities of what is known as "raw glass" are made in Bohemia. This glass furnishes the raw material of other establishments, and is in these establishments decorated, polished, and made into looking-glasses, beads, etc.

There is but one plate-glass works in Austria-Hungary, as the manufacture of plate-glass has not been a very successful enterprise in that country. The first works was established in 1700, and, after leading a peripatetic existence, was finally abandoned in 1840. The plate-glass works now in operation is at Stockau, in Bohemia. The glass is chiefly used for the manufacture of mirrors. Considerable window-glass is also made in Austria, much of it for the manufacture of looking-glasses, for which large sizes are blown, the workmen using levers, cranes, props, and other mechanical means in its production. The finishing of this glass is carried on in the Pilsen district, where there is a number of establishments for grinding and silvering. There are in Austria 63 glass factories making cylinder glass, 46 making what is called cast glass, mainly for mirrors, and 56 making both.

The chief seat of the Austrian manufacture is in Bohemia, 169 of the 360 furnaces reported below being in that district. The glass houses, however, are generally very primitive affairs, being in the midst of forests, the furnaces ordinarily very small, containing seven or eight small pots, and burning wood. These furnaces, being so rude and inexpensive, are placed in the midst of the timber. As the fuel around a factory is burned, it is found more economical to move the furnace than to bring the fuel to it. This state of affairs has resulted in the division of glass-making in Bohemia into two distinct branches, the manufacture or the production of the rough unfinished articles and the manipulation—the so-called refining, or the cutting, engraving, and decorating of this raw glass. In a few establishments both operations are carried on, but the larger number simply blow or mold the articles and sell them to the glass refiner. The result of this division has been the training of a body of excellent engravers, and the skill has been still further encouraged by a government museum; and drawing- and art-schools in connection with the glass industry have also been opened at various places. As is stated in the chapter on materials, sand is but seldom used in Bohemia, quartz, which is quite abundant, being substituted for it.

According to the last statistical reports published in 1880 there are in Austria-Hungary 230 firms, operating 255 glass houses, in which there are 360 furnaces. In these furnaces are 2,803 open pots, 37 covered pots, and 5 tanks. Of the 360 furnaces, 15, with 123 pots, are regarded as permanently idle; 7 furnaces, with 50 pots, as temporarily idle; 1 furnace, with 8 pots, and 1 Siemens tank-furnace were in course of construction. The location of these furnaces and the number of workmen engaged are as follows:

Location of furnaces.	Glass houses.	Furnaces.	Workmen.
Bohemia.....	123	180	18,012
Moravia.....	16	27	9,072
Silesia.....	3	3	94
Galicia.....	15	15	358
Buckowina.....	4	5	111
Lower Austria.....	8	14	405
Upper Austria.....	3	4	170
Salzburg.....	1	2	300
Styria.....	20	27	1,142
Kaernten.....	2	2	60
Krain.....	2	4	109
Tyrol.....	4	5	109
Dalmatia.....	1	1	24
Hungary.....	40	66	2,850
Croatia.....	4	6	170
Slavonia.....	3	4	155
Transylvania.....	0	0	200

Helpers are not included in this estimate. If we add to this number 21,500 workmen engaged in glass refineries and other factories of a kindred character, we may put the number of workmen engaged in the glass industry of Austria-Hungary at 60,000.

Of these 360 works, 1 manufactures plate-glass, 1 cathedral glass, 63 window-glass, including blown looking-glass and colored glass, 71 table ware, 131 hollow glass, including crystal and fine glasses, 20 lamps, 50

## MANUFACTURE OF GLASS.

green glass and bottles, 15 colored raw glass (9 of these are window-glass, and are included in window-glass manufacture), 15 raw glass sticks and pipes for beads, and 2 pressed glass. As stated above, wood is the chief fuel used. Of the 360 furnaces, 244 use wood as fuel, 86 peat, 18 coal, and 12 turf and wood.

One hundred and forty-six glass houses manufacture cut glass and other fine ware. Of these, 47 use foot-power, 57 water-power, and 16 steam-power. The total annual production of Austria reaches in value about \$12,000,000. I find a statement in the *Bulletin of the Society for the Encouragement of the National Industry in France* to the effect that, in 1873, 70,000 to 80,000 quintals of blown window-glass were made in Bohemia in that year.

**MANUFACTURE OF GLASS IN ITALY.**—The recent revival of the manufacture of Venetian glass, while it has not added largely to the amount or value of the production of Italy, has given to its glass a reputation that has been wanting since the fires of Murano went out. In 1866 the Venice and Murano Glass Company was established by a few English gentlemen for the purpose of restoring the manufacture of Venetian glass, and the result has been a degree of excellence in product not unworthy of comparison with that which in former days characterized the productions of the glass works of Venice and Murano. Through the kindness of Signor G. Castellani, to whose skill the modern glass houses of Venice are so much indebted, I have received the following statement regarding the works at Murano:

Murano, a small island twenty minutes distant from Venice, contains 4,000 inhabitants, 2,000 of whom are employed in glass works. In these works are made beads, sheet window-glass, blown-glass articles, (a) vases, table ware, etc., chandeliers, bottles, green druggists' ware, and enamels for mosaics. There are ten or twelve furnaces in these different establishments. The most important of the Murano works, in a commercial point of view, is *La Fabbriche Unite*, where beads are made, about a thousand workmen being employed. The Venice and Murano Company, which is the principal factory for blown and artistic glass, employs about seventy men, part of whom are called *maestri*. Its production is limited, the number of *maestri* being very small and not easily increased. The production amounts to about 500,000 francs (\$96,500) a year. The entire product of the island does not exceed 5,000,000 francs (\$965,000) a year. All the materials used on this island are drawn from other countries; the sand from Dalmatia, soda from England, coloring matter chiefly from Germany.

As to the details of the manufacture of glass in other parts of Italy but little information is obtained. The following statement was obtained from the minister of foreign affairs of Italy through the late Mr. Marsh, American minister:

Kinds of glass.	No. of establishments.	Average number of employes.
Plate-glass.....		
Window-glass.....	12	1,200
Glassware.....	49	3,000
Green glass.....	14	800
Total.....	75	5,000

**MANUFACTURE OF GLASS IN RUSSIA.**—The development of the glass industry in Russia in the last fifteen years has been very marked. All kinds of glass are made in this empire: plate, window, glassware, and bottles. As a rule, however, the works are quite primitive. In the Wilna, Minsk, and neighboring districts only wood is used. The furnaces are very primitive, and average but from four to six pots. In the central district, however, where there are fifty-eight works, the establishments are somewhat larger. The plate-glass establishment is in the northeast district. The entire production of Russia can be placed at about 10,000,000 rubles, or \$7,779,000. The number of glass factories in Russia in 1879 was 202, the number of persons employed 14,480.

**MANUFACTURE OF GLASS IN SWEDEN.**—Sweden manufactures glass somewhat more extensively than Norway, supplying not only the larger part of its own demand, but having some surplus to export to Russia. Its quality, however, is not remarkable, and but little attention is paid to the production of anything but the commoner grades, though some painted glass is made. There are in Sweden 33 glass works, producing window-glass, glassware, and bottles, no plate-glass being made. Of these, 4 manufacture window-glass, making 19,602 cases yearly, (b) 15 glassware, and 14 are green-glass factories. In these 33 works are 38 furnaces, with 280 pots and 1 tank. Seven furnaces use gas, 3 coal, 2 peat, and 2 wood, and 31 are direct-firing, using wood as a fuel. The statistics of these factories for 1879 are as follows: (c)

Kinds of glass.	No. of establishments.	No. of furnaces.	No. of pots.	NUMBER OF EMPLOYÉS.			Value of product.
				Men over 16.	Women over 16.	Males under 16.	
Window-glass.....	4						\$93,955
Glassware.....	15						295,547
Green glass.....	14						263,323
Total.....	33	38	{ 280 pots } { 1 tank. }	1,200	50	800	654,825

a Known as Soffiati.

b These cases are probably of 100 feet each.

c For these figures I am indebted to the courtesy of Mr. Fredr. Brushewitz, of Limmared, Sweden.

MANUFACTURE OF GLASS IN NORWAY.—But little glass is made in Norway. There is but one window-glass factory which uses wood as a fuel in a direct-firing furnace; two flint works making table ware, one using a Boetius and the other a wood-gas furnace, and three bottle houses using Siemens furnaces, two with pots and one tank. The latest statistics at hand, which are only approximately correct, are as follows:

Kinds of glass.	No. of establishments.	No. of furnaces.	No. of employes.	Value of product.
Window-glass.....	1	1	35	\$27,000
Glassware.....	2	2	300	33,500
Green glass.....	3	3	270	33,500
Total.....	6	6	605	200,000

Of the employes 25 are women and 112 are children.

MANUFACTURE OF GLASS IN SPAIN.—Though Spain was one of the first nations of western Europe to make glass, the present condition of this industry by no means justifies the promise of its beginning. There existed in Catalonia, Spain, in the last century many works famous for their beautiful glass, but these are nearly all closed. In the whole of this kingdom at the present time there are only some 23 or 24 glass houses, making bottles, lamp articles, and window-glass, mostly for local use, though some little is exported. At these factories, also, some rude and strange shaped vessels and drinking-cups are made, and these, compared with the specimens remaining, show that the old forms and the old systems of ornamentation are still in use.

GLASS IN HOLLAND.—There are in Holland 19 glass works, all but one of which are engaged in the manufacture of the peculiar square glass bottles used for bottling the Dutch spirits. Many of these bottle factories are in connection with the distilleries, and consequently have a steady business, but little affected by foreign competition. The total production is about 19,000,000 a year, all colored. In addition to these bottle factories there is a glassware works at Maastricht.

The province of Zealand furnishes a substance largely used in the manufacture of plate-glass, "bergasche", supposed to be the remains of a salt-boiling works which once existed in that province. This substance takes the place of soda, but requires especial preparation.

GLASS IN PORTUGAL.—In Portugal there is one establishment for the manufacture of crystal and fine glass, and some glass of other kinds is made, but not enough for the needs of the country.

## CHAPTER XII.—HISTORY OF GLASS-MAKING IN THE UNITED STATES.

### GLASS-MAKING IN VIRGINIA AND WEST VIRGINIA.

One of the first attempts at manufacturing within the limits of the thirteen original colonies was the production of glass. The hopes of sudden wealth from the discovery of gold and silver, or from finding the fabled passage through this continent to the South Sea, were doubtless the chief causes of the formation of the London Company and its early attempts to colonize Virginia. At the same time, this was a commercial venture, with the hopes of profit, and with a shrewdness characteristic of the English merchants, not only of that but of subsequent centuries, they did not forget entirely the possibilities near at hand in their search for what they believed would be greater ones in the near future. The vessel which carried Captain Newport to this colony on his second voyage, in 1608, also brought out eight Poles and Germans to make "pitch, tar, glass, mills, and soap-ashes". Stith wisely remarks that "had the country been peopled they would have done well, but they only proved a burden and a hinderance to the rest". (a) After the return from the fruitless expedition to the country of the "Manakins", the president of the colony, Captain Smith, dispersed as many as "were able, some to make glass, and others for pitch, tar, and soap-ashes". Between the arrival of Captain Newport and the return of his vessel, in 1608 or 1609, some glass was made, and part of the return cargo, the first that conveyed any exports of manufactures from what is now the United States, was the trials of glass thus made.

Stith states that the glass house in which the glass was manufactured, and which was probably the first manufactory erected in the English colonies in America, being erected late in 1608 or early in 1609, stood in the woods about a mile from Jamestown. This enterprise was one of some daring. Glass-making at this time was by

no means well established in Europe. Flint-glass was not yet invented, and plate was not cast, while the art of blowing window-glass and bottles and making glassware was imperfectly practiced in England. Wood, however, was becoming scarce, and the alkalis needed for the manufacture of glass high priced, and those of a good quality were brought from a distance. All of these materials were not only abundant in the new colony, but the wood was a burden and potash could be made readily from the wood-ashes. The great bulk of glass bottles made their importation expensive, and it is possible that the first glass house in Virginia made bottles only. What window-glass was used was imported.

The craze for the raising of tobacco, which had such a disastrous effect upon the colony, interfered with glass-making, and in 1617 Captain Argall, on his arrival as governor, found the glass house fallen to decay. (a) In 1620 an attempt was made to restore manufactures to the colony, and a large number of artisans was sent to Virginia. In 1621 a roll or subscription was opened to raise funds for the erection of a glass house to make beads for the Indian trade, and Captain Norton and some Italians were sent over for that purpose. The subscribers to these rolls were to participate in the profits. These beads were currency among the Indians.

The London Company, in its letter of July, 1621, sent in the ship *George*, commended this Captain William Norton to the governor. He was directed to be lodged in the Guest House with his "gange" until he had found a convenient place for his furnace, and in the choice of place care was to be taken that he and his "gange" be as secure as possible from surprise, "so that the commoditie of glass and beads should not be vilified by too common a sale to the Indians". (b) At the time of the massacre, in 1622, the glass house at Jamestown was destroyed, but it does not appear that these Italian glass-workers were massacred, as they must have been had their glass works been at this place. They are referred to in June, 1622, and again in February 20, 1623, by the governor and council in a letter to London, in which they state that a gentleman who was returning to London would inform the company what had been done. This would seem to indicate that the manufacture of beads was not carried on at Jamestown, but that the house that was destroyed was the first one.

What was the history of glass for some years after this date is not, so far as I have been able to discover, a matter of record. No doubt the colonists found that the cheapness of fuel and of alkali was more than offset by the scarcity and high price of labor and its tendency to seek other employment, and it is probable that glass making was abandoned.

The next account of a glass works in Virginia that I have found is of one that was in existence in 1787 at Alexandria. M. De Warville, who visited this state in the fall of 1788, states that this works exported the previous year glass to the amount of 10,000 pounds and employed 500 hands. This is the last notice of a works in eastern Virginia until early in the nineteenth century. Mr. Jarves states that a Dr. Adams, of Richmond, Virginia, "made large offers of increased wages to the workmen of the Essex-street works, who were induced to abandon their places of work and violate their indentures. They succeeded in reaching Richmond to try their fortune under the auspices of the doctor. A few years' experience convinced them of the fallacy of increased pay, for, after very heavy losses, the works were abandoned and the workmen thrown out of employ".

This is the last record I have been able to find of a glass works in eastern Virginia, or what is now Virginia.

In the census of 1810 Virginia does not appear as a glass-making state. In 1815, however, a glass works for making white flint, hollow, and other glassware was established at Wellsburg, in the western part of the state, at which glassware of an excellent quality was produced. In the census of 1820 a glass works is reported in Brooke county, which was no doubt the Wellsburg works. It made that year \$20,000 worth of glass, had \$12,000 capital, and paid out \$8,000 for wages and \$12,000 for material and contingent expenses, or exactly the value of product. It employed 14 men and 12 youths. In 1827 it is reported that glass decanters of great beauty and solidity were made at these works, "while white flint and green glass wares made within a few years rivaled the foreign."

At the tariff convention of 1831 there were two flint-glass furnaces, with 12 pots, reported in operation at Wellsburg, Pennsylvania, evidently a misprint for Virginia, and one with 6 pots at Wheeling, Virginia. Two window-glass works are also reported at Wheeling. In 1840 one glass works is reported in Brooke county (the Wellsburg), and three in Ohio county (the Wheeling).

Regarding the history of the Wheeling factories, Mr. W. Leighton, jr., in an article contributed by him to the *Wheeling Sunday Leader* of March 28, 1880, in some reminiscences, states that—

The first glass factory built in Wheeling was for the manufacture of window-glass, and the business was commenced some time in the year 1821. I find in the *History of the Pan-Handle* that "in 1829 a flint-glass house was erected in Wheeling by John and Craig Ritchie, located on the side of the hill opposite the second ward market-house. This establishment was operated for several years with great activity and success, and had a widespread reputation for the manufacture of fine-cut glassware. This success and the unrivalled advantages for procuring cheap fuel at Wheeling encouraged other firms to embark in the business, and in 1835 the Messrs. Sweeney put a large flint-glass works into operation in the northern part of the town, which was followed in the course of the next few years by the erection of another large establishment at the extreme south end, built by Plunket & Miller, now owned and operated by the firm of J. H. Hobbs, Brockunier & Co."

a Captain Smith, under date of 1615, states that for a long time the labor of the colony had been misdirected in the manufacture of various articles, among them glass.

b Neal's *Virginia Company of London*, page 231.

The veteran glass manufacturers of this country, Mr. J. L. Hobbs, and his son Mr. J. H. Hobbs, of the South Wheeling glass works, have been, I believe, for a longer time uninterruptedly running their furnaces than any other glass manufacturers in the United States. These gentlemen came to Wheeling in 1845 and purchased the glass works built by Messrs. Plunket & Miller, since which time there has been no break or interruption to their business.

Whether or not the introduction of glass-making at Wheeling encountered the same difficulties as are described to have met Mr. Bakewell at Pittsburgh I do not find set down in the records, but the probabilities are that a similar experience was had. The factories, however, ultimately surmounted all difficulties, and went on to good success. In 1863 the Central Glass Company was established by a number of workmen from the South Wheeling glass works and successfully operated. At later dates several other factories have been built in this valley, among which are the Belmont Company and Goblet Company at Bellaire, the La Belle Company at Bridgeport, and the Excelsior Company at Martin's Ferry. Beside these, window-glass factories and lamp-chimney houses have been located here, and the amount of glass business in this vicinity is assuming year by year greater proportions.

The obvious reason for the establishment of glass factories in Wheeling has already been mentioned—its cheap fuel. This has always been an important consideration; but the success of glass-making here has not been due to this cause alone; it owes much of its prosperity to the enterprise of those engaged in it. While the first great step of progress in glass-making in modern times, the invention of pressing, is claimed, as before mentioned, to be American, so is the second not only American, but had its origin here in Wheeling. This second step was the improvement in the composition of lime glass, which enabled manufacturers to substitute that material in place of the old flint-glass.

For the manufacture of bottles, window-glass, jars, and shades in England and on the continent of Europe lime glass has always been used, and can boast an antiquity perhaps as great as that of flint-glass. The first factories in this country made window-glass, using, of course, the lime composition; the manufacture of bottles followed, but flint-glass making was commenced, and, as in Europe, only inferior grades of ware were made of lime glass. In Pittsburgh, at an early period, common tumblers and cheap table ware were made of lime glass, and some improvement had been made in 1864; but still the lime goods were so much inferior to flint-glass as not to come in competition with it, their lack of purity and luster being very conspicuous faults.

In the winter of 1864 Mr. William Leighton, sr., of the firm of J. H. Hobbs, Brockunier & Co., made a course of experiments in the composition of lime glass, the result of which was so successful that the manufacture of lime glass was commenced by his firm, and ware was produced equaling in beauty the finest flint-glass. The most important feature in the composition of this new lime batch was the use of bicarbonate of soda in place of soda-ash, until that time universally used in lime glass; and this use of bicarbonate, and better proportion of all the materials, constituted the improvement, and led to the most important results. As the improved lime glass was much cheaper than flint-glass, being less than half its cost, other factories commenced using the same material and learned the new composition. The ware thus manufactured could only be distinguished from flint-glass by its less specific gravity, and by the peculiar tone of its sound when struck, the flint-glass having a full metallic tone or ring, while the lime glass emits a dull, dead sound, destitute of vibratory tone. From the time of this improvement in lime glass the flint-glass factories began to languish. The larger number of them, perceiving that the era of flint-glass was past, gave up the old composition and commenced the manufacture of bicarbonate glass, as it was then called. But a few factories still clung to the old lead-glass composition, fondly hoping, and perhaps believing, that lime glass would run a brief course, and that there would be a return to the time-honored flint-glass. It soon became evident, however, that lime glass had gained the ascendant by merits that would stand the test of time, and those who still persevered in the manufacture of lead glass found their ware could no longer be profitably made, and gained the experience that, in an age of progress, whoever clings to the methods of the past will soon be neglected and forgotten.

Beside advantage of cheaper material, lime glass has the property of chilling and becoming rigid more quickly than flint-glass, thus enabling, and even compelling, the workmen to finish the ware more rapidly, and hence making a greater production; and as the specific gravity of lime glass is less than that of flint-glass, articles made of the former have the advantage of this lightness of weight. The result of all these advantages, together with improvements in furnaces, tools, and methods of manufacture, has been to reduce the cost of glassware to about one-fourth part of what it was when the invention and introduction of bicarbonate glass took place in 1864. With this reduced cost, and consequent reduced price, the use of glassware has been extended correspondingly. New factories have been built; old factories have increased their capacity; and a sufficient supply of glassware has been produced to meet the demand which the reduced prices created.

No kind of ware, even if composed of the most common materials, can now compete in cheapness with lime glass for drinking-vessels and table ware; while for beauty of material, finish, shape, and ornamentation glassware is more than equal to, and for cleanliness far beyond, any other.

Speaking of gas furnaces, Mr. Leighton says:

Although Wheeling took no part in experimental gas furnaces, yet as soon as it became evident that a safe form of construction had been reached, that form was at once adopted here. The largest gas furnace for melting glass in this country, and probably in the world, was built and put into operation last year by Messrs. J. H. Hobbs, Brockunier & Co., at their South Wheeling glass works, and after six months' trial they were so well satisfied with its results that they put up another of the same form of construction, which has just been completed.

#### GLASS-MAKING IN PENNSYLVANIA.

The first mention of a glass works in Pennsylvania is found in a letter written in August, 1683, by Penn to the Free Society of Traders. In this letter he alludes to their tannery, saw-mill, and glass-house, "the last two conveniently posted for water carriage." Where this glass house was located, or for what kind of glass it was intended, is not known; indeed, it is doubtful whether the works were ever used for the purpose for which they were erected. If they were, they proved unsuccessful, as did most of the early glass works in the colonies, and were soon abandoned. (a)

a Budd, who wrote in 1685, does not mention them. Dr. More's letter, printed in 1687, mentions a number of industries, but not glass-making, and the same is true of the pamphlet printed some time in 1691, entitled *Letters and an Abstract of Letters from Pennsylvania*. In this pamphlet all the trades which flourished in Pennsylvania are mentioned, but glass is not one of them. Holme, who wrote in 1689, and who refers to a number of trades that were carried on in Pennsylvania, speaks of the scarcity of window-glass. He writes:

The window-glass is often here  
Exceeding scarce and very dear,  
So that some in this way do take  
Isinglass windows for to make.

There is a statement in Bishop's *History of American Manufactures* to the effect that a glass works was built shortly after this one at Frankfort, near Philadelphia, by the English Friends who settled there, but this is probably a mistake, as there were no English Friends in Philadelphia at so early a date. (a)

From this time until just before the Revolution the record of glass-making in Pennsylvania is a blank. Governor John Penn, in a letter to the Lords of Trade and Plantations, dated Philadelphia, January 21, 1767, wrote:

The other is a glass manufactory, which was erected about four years ago in Lancaster county, seventy miles from this city, by a private person. It is still carried on, tho' to a very inconsiderable extent, there being no other vent for their ware, which is of a very ordinary quality, but to supply the small demands of the villages and farmers in the adjacent inland country. (b)

This was probably Baron Steigel's establishment, referred to below, who established himself at Manheim in 1762; but however this may have been, there is evidence that Steigel soon after this built a glass house. In June of the same year that Penn's letter was written (1767) Townsend's scheme for raising revenue from the colonies passed the British parliament and was met in this country by a storm of denunciation and agreements of non-importation. At public meetings it was determined to stimulate by all prudent ways and means the manufactures of the colonies, and glass and paper were particularly mentioned as articles deserving of domestic encouragement. Townsend's revenue act was repealed in 1770. At that time a flint-glass manufactory on a much larger scale than any before attempted in the country had been built at the village of Manheim, near Lancaster, by a German baron, Henry William Steigel, and Mr. David Rittenhouse, in a letter to Mr. Barton, dated the 4th of February, 1770, speaks of his intention when he next visited Lancaster to have some pulse-glasses, then just introduced by Dr. Franklin from Germany, and other things he wanted, made there. In another letter, written in the following summer, acknowledging the receipt of a barometer tube made at this factory, he says:

I am obliged to you for the glass tube; it will make a pretty barometer, though the bore is somewhat too small. I have compared it with an English tube, and do not think the preference can with any reason be given to the latter. (c)

This enterprise did not prove remunerative, as the war interfered with remittances from Europe and embarrassment ensued, and the glass works were abandoned. (d)

About the time that Steigel built his factory at Lancaster the first glass works in Philadelphia of which we have any details was established at Kensington. The repeal of Townsend's act did not remove the determination of the people of the colonies to establish domestic manufactures in their limits, and though workmen skilled in the manufacture of glass were by no means common, some gentlemen engaged in trades quite foreign to glass-making were found who were willing to risk their capital in this undertaking. In October, 1771, Robert Towars, skinner or leather-dresser, and Joseph Leacock, watchmaker, purchased a piece of land on the east side of Bank street (now Richmond street) and built upon it a glass house, furnace, and other improvements. (e)

This works must have begun the manufacture of glass late in 1771 or early in 1772, and it certainly made green bottles, and perhaps flint ware. In Franklin & Hall's *Pennsylvania Gazette* of January, 1772, appears the following advertisement:

The glass factory, Northern Liberties, next door to the sign of the Marquis of Granby, in Market street, where the highest price is given for broken flint-glass and alkaline salts.

This would indicate the manufacture of flint-glass. The place designated was the store of Robert Towars, which was in Market street, between Second and Third streets. In November, 1772, Towars and Leacock sold the premises to John Elliott and Samuel Elliott, druggists, who took into partnership and interest Isaac Gray. These partners built an additional furnace and continued the manufacture of bottles, carrying on the business for eight years, and as the Elliotts were apothecaries and Gray was a wine merchant, it may be supposed that in this venture the manufacture of bottles for use in their business was an object. The property was sold in May, 1780, to Thomas Leiper, a tobaccoist, who must have needed many bottles for the reception of snuff. The latter was owner for twenty years, and sold the glass house on March 6, 1800, to Joseph Roberts, jr., James Butland, and James Rowland for \$2,333, subject to £15 ground-rent, who carried on the works under the firm name of James Butland & Co., and in 1801 had their store at No. 80 North Fourth street. Roberts soon sold out his one-third interest to Butland and Rowland for \$2,548, who dissolved partnership in 1804, Butland disposing of his interest to Rowland for \$2,548, and the latter advertised in 1808 that his store for the sale of bottles made at the Kensington glass works was at No. 93 North Second street. He was also in business as an iron merchant. James Rowland died before the year 1833, and on July 10 of that year James Rowland, jr., who had purchased the interest of his brother, Joseph W. Rowland, sold the works to Dr. Thomas W. Dyott.

Though the records are very meager, there are evidences that several other glass works were built in eastern Pennsylvania between the breaking out of the revolutionary war and the close of the century, and no doubt the

a Mr. F. D. Stone, the librarian of the Historical Society of Pennsylvania, writes me that Pastorius was the agent of the Frankfort Land Company, and Bishop probably confounds this name with the little town of Frankford, now a part of Philadelphia.

b *Pennsylvania Colonial Records*, ix, 354.

c Barton's *Memoirs of Rittenhouse*, page 206.

d In Franklin & Hall's *Pennsylvania Gazette* for January, 1772, in addition to the advertisement for broken flint-glass, elsewhere referred to, is one from the Southwark china factory for flint stones and broken glass. This may have been for "cullett" for the Lancaster works, or for some other factory of which we have found no record.

e For most of the earlier details of this works I am indebted to Thompson Westcott's history of Philadelphia, published in the *Philadelphia Sunday Dispatch*.



It was stated that this glass was composed of "materials altogether the production of American soil, about 15,000 barrels of rosin from North Carolina being annually consumed as fuel in preference to wood or coal". From 250 to 300 men and boys were constantly employed. In 1833 this works had five furnaces, wood and coal, as well as rosin, being used for fuel. It may be well to follow out the history of these works in this place. They were operated for several years after this until the disastrous failure and conviction of Dr. Dyott in 1838 for fraudulent insolvency, when the works passed into other hands, and after being idle for some years were leased in 1842 by Henry Seybert, who became interested in the glass business principally for the purpose of assisting Eugene Roussel in obtaining a supply of bottles for the manufacture of mineral or aerated water, then just being introduced into the United States. He also made flint in one furnace. In 1843 they were leased by a partnership, of which Mr. Henry B. Benners, the present proprietor, was a member. This works is still in operation, the oldest glass works in Philadelphia, and probably in the United States, with a record of one hundred and eleven years of work.

Returning to 1810, the date of the first census of manufactures, we find reported in Pennsylvania, outside of Allegheny county, five glass houses—one in Philadelphia city, two in Philadelphia county, and one each in Lycoming and Wayne counties. The value of the product of the Wayne county works is given at \$36,000, while that of the three Philadelphia works was only \$26,000. The Lycoming county works, which was probably at Williamsport, had a product of \$20,000. This would indicate that glass-making in Philadelphia was not a prosperous business. At the census of 1820 but one works is reported in Philadelphia county, "a flint-glass works, that had been out of operation for some years", while in Wayne county a window-glass works, with one furnace and six pots, is reported, which had been "in operation for five years with good success". Jarves also states that in 1820 a number of workmen left the New England Glass Company at East Cambridge, Massachusetts, and established a co-operative flint-glass works at Kensington under the title of the Union Flint Glass Company; but after a few years this works passed into other hands, and the first recorded attempt at co-operative glass-making in this country failed.

In 1831, as already stated, the Dyottville works were the most extensive in the country. There was also in Philadelphia a flint-glass works with six pots. No mention is made of the Wayne county works at this time, though it appears at the census of 1840. There were, however, two works in Lycoming county, at Williamsport, one for the manufacture of window-glass and the other for hollow ware (green glass, etc.). In 1840, according to the census, there were but two glass works in the eastern district of Pennsylvania: one in Philadelphia and one in Wayne county. But it is not necessary to follow the history of glass in this section further. While there has been glass made in increasing quantities in eastern Pennsylvania since 1840, the industry has not attained the importance it has reached west of the mountains. It may be interesting to state, however, that though window-glass was at one time made in Philadelphia, none has been made in that city for seven years.

Of early glass-making in western Pennsylvania quite full accounts remain, and at least four of those connected with the earliest works, Albert Gallatin, Colonel James O'Hara, Major Isaac Craig, and Major Ebenezer Denny, were prominent in the affairs of the nation. Their journals and papers have been saved from the destruction or oblivion that usually overtakes such documents, and from these very satisfactory statements of these early undertakings can be obtained.

The generally received opinion for some years has been that the first glass works west of the Allegheny mountains was built by Albert Gallatin at his settlement of New Geneva, on the Monongahela river, some 90 miles south of Pittsburgh. Here Mr. Gallatin established a number of industries, and among them that of glass-making. Various dates have been assigned to his glass works, the most common one being 1787; but the evidence is quite conclusive that this is an error, and that the works was not started until 1797. (a)

Not only is the date usually assigned to this works incorrect, but it is very probable that it is not entitled to the credit of being the first west of the Alleghenies, Craig & O'Hara making glass about a month earlier. (b) As the Gallatin works was isolated and so remained, not forming, as did Craig & O'Hara's, the nucleus of a great industry, it may be well, though it was not the earliest, to give its history first, that the account of the works at Pittsburgh may be a connected one.

The Gallatin works was used for the manufacture of window-glass. The furnace was a small one, with eight pots, using wood as a fuel and "ashes for alkali". The glass house was 40 by 40 feet, three sides frame and one side stone. The most credible story regarding its erection is that a number of glass-workers, mostly Germans, left Amelung's factory (c) at Fredericktown, Maryland, and crossed the mountains for the purpose of building a glass works at the point that is now Louisville, Kentucky. Gallatin accidentally met them at Wheeling and persuaded

a In Adams' *Life of Gallatin*, Philadelphia, 1879, it is stated that the business of "glass-making" at New Geneva began "during Mr. Gallatin's absence in the spring of 1797". This is confirmed by Mr. Isaac Craig. (See note below.)

b I am informed by Mr. Isaac Craig, of Pittsburgh, the grandson of Major Craig, who has in his possession many of the letters that passed between Major Craig and Colonel O'Hara on the subject of the glass works, and who is one of the best authorities on the history of western Pennsylvania living, that as the result of a correspondence between himself, Mr. Henry Adams, the author of the *Life of Gallatin*, before referred to, and a son of Mr. Gallatin, he is convinced that the Craig & O'Hara works began to make glass a month earlier than Gallatin's. The Pittsburgh works began in 1797 without doubt, and this would fix the date of Gallatin's as 1797 also. Mr. Craig has kindly allowed me free access to his grandfather's letter-books.

c See account of this works under "Glass-making in Maryland". It is probable that Mr. Amelung was at one time a glass-worker at Pittsburgh. In *Cumming's Journal*, about 1807, mention is made of A. F. Amelung, a glass-worker in Pittsburgh.

them to turn back to New Geneva and establish the works there, Mr. Gallatin agreeing to furnish capital and they to do the blowing. (a) The title of the firm at first was Gallatin & Co., but it was afterward changed to the New Geneva glass works.

For a time the business was exceedingly profitable, more so, Mr. Adams tells us, than any other of Mr. Gallatin's enterprises. (b) There were but two, possibly three, other window-glass factories in the country, most of the window-glass used coming from England. These works, as well as Craig & O'Hara's, were on or near the route of travel between the East and the rapidly developing West, and the glass commanded a ready market. There seems to have been considerable discussion between Mr. Gallatin and his partners, among whom were a Mr. Nicholson and two brothers by the name of Kramer, who were skilled workmen and had charge of the manufacturing of the glass, as to the price at which it should be sold, and it was fixed at \$14 a box of 100 feet, (c) though Mr. Gallatin, fearing ruinous competition by reason of the profit at this price, favored a lower rate. The glass, however, by reason of the character of the materials used, was probably of an inferior quality. The works was removed in 1807 to the other side of the Monongahela river, and in 1814 it was operated by Nicholson & Co. (d) As late as 1832 a glass house was reported at New Geneva, and glass was made some years later than this. When the works was finally abandoned I have not been able to learn.

In 1796 preliminary steps were taken by Major Isaac Craig and Colonel James O'Hara toward the erection of the first glass house at Pittsburgh. (e) This was also the first works west of the mountains to make glass, Mr. Peter William Eichbaum, a German glass-worker, who was superintendent of glass works at the Falls of the Schuylkill, near Philadelphia, being engaged to direct their erection. (f) Various causes delayed the work, and it was not until 1797 that the active work of building the furnace was begun, when, as appears from a letter written June 12 of that year by Major Craig to Colonel O'Hara, (g) search for coal in the upper part of what is now Allegheny City not showing a vein of workable thickness, a location on Coal Hill, on the south side of the Monongahela river, just above where it unites with the Allegheny to form the Ohio, was purchased, and the erection of the furnace was begun. This site, or part of it, has ever since been continuously occupied by a glass house, the Point Bridge works of Thomas Wightman & Co. occupying it at present.

This was one of the first, if not the first works in the United States to use coal as a fuel; (h) indeed, as late as 1810 coal was not used in any glass works in this country but the Pittsburgh houses. (i) It was not the force or circumstances or lack of wood that led to the use of coal, but it was the deliberate design of the promoters of this enterprise to melt their glass with coal, and it was the character of the coal in Coal hill that determined the location of the works. (j) The use of coal in the state of the art at this time required considerable determination and risk, and it is to the credit of these gentlemen that they dared use it.

The generally received belief that this was the first glass works in Pittsburgh was called in question a few years since by the statement that in 1795 there was a window-glass works, known as "Scott's", at Glass House rifle, on the west bank of the Monongahela. (k) This is without doubt an error. Mr. Neville B. Craig, in his *History of Pittsburgh*, speaks of the O'Hara works as "the first glass house here", and as his memory went back distinctly to 1796, if not earlier, it is hardly possible he would not have known of this "Scott's" works if it existed in 1795. It is probable that the works referred to was the "Ohio" works, built about 1800 by Denny & Beelen, which was on the north side of the Ohio, and which gave the name to Glass House rifle, as it appears from a letter of Major Craig's, in connection with the experiment of Mr. Price, that Dr. Hugh Scott, from whom it got its name,

a *History of Fayette County, Pennsylvania*. Philadelphia, 1882.

b *Life of Gallatin*, p. 176. Mr. Adams writes me, however, that the glass works were "a constant matter of anxiety" to Mr. Gallatin.

c This does not seem so extravagant a price when it is known that at the census of 1810, when there were at least fifteen works in the country making about 5,000,000 square feet of window-glass a year, the marshals estimated the value of the glass at 16 cents a square foot.

d Cramer's *Navigator*, 8th ed., p. 40. Pittsburgh, 1814.

e *History of Pittsburgh*, p. 276. By Neville B. Craig. Pittsburgh, 1851.

f I have before me a letter from Mr. Eichbaum to Major Craig, dated Falls of the Schuylkill, August 18, 1796, from which it appears that negotiations had been in progress for some time between these gentlemen looking to the building of the glass house, and "four different sorts of clay" from near Pittsburgh had been sent Mr. Eichbaum for his judgment as to their adaptability for pot-making. He writes they "do not look amiss" with the exception of some roots, and gives directions for the digging and ripening of 20 or 25 tons weight. This letter is in answer to one from Major Craig, of June 6, 1796, in which he had evidently made a proposition to Mr. Eichbaum to go to Pittsburgh, which the latter accepts conditionally if Messrs. Craig & O'Hara's resolve to build glass works is "absolutely fixed".

g Craig's *History of Pittsburgh*, pp. 276, 277.

h Gallatin's works used wood, as did Denny & Beelen's, the third west of the mountains.

i See Gallatin's *Report on Manufactures in 1810*.

j The Glass House rifle works referred to below used wood, its location on the north bank of the Ohio rendering this necessary.

k See *Pittsburgh as It Is*, by George H. Thurston, Pittsburgh, 1857; also Bishop's *History of American Manufactures*, which probably follows Thurston. Mr. Thurston's authority is a statement of the late Mr. William McCully, a well-known Pittsburgh glass manufacturer, who learned the trade of window-glass blowing in the Craig & O'Hara glass house. I think there can be no doubt but that Mr. Thurston either misunderstood Mr. McCully, or that Mr. McCully was mistaken. Mr. Mark Watson, Mr. McCully's son-in-law and his successor in business, authorizes the statement that in their many conversations on the subject Mr. McCully always spoke of the Craig-O'Hara house as the first. Mr. Isaac Craig also states that, as early as 1845, Mr. McCully told him that the Craig & O'Hara works was the first.

was in 1800 connected with this works. There seems to be no doubt that the Craig & O'Hara works was the first glass works not only in Pittsburgh, but west of the mountains, and was the pioneer of Pittsburgh's glass industry.

The building erected was frame, and contained an eight-pot window-glass furnace using coal as fuel, three boxes being made at a blowing, the box at that time containing 100 square feet. What is now known as a box, 50 square feet, was formerly, even as late as 1860, termed "half box (H. B.)", and the rates of wages for blowing are still based on the box of 100 feet. Some idea of the pots in this pioneer factory can be obtained from the output. A box of 100 feet did not probably exceed 125 pounds in weight, which would give 375 pounds as the finished product of the blowing or of one blower at each melting, and allowing that the weight of product was four-fifths of the weight of batch, the amount of material charged into each pot would be but 500 pounds. Now the weight of batch in each pot will average 1,500 pounds, and the average of a blower is nine to ten boxes of 100 feet. An old glass manufacturer expresses this difference in the size of the pots very graphically in saying: "One man could easily lift an old-style pot, now it takes four men."

As was generally the custom in the window-glass houses of that day, one or more pots in the furnace were used for the manufacture of bottles—"hollow ware," as they were termed. Among Colonel O'Hara's papers, found after his death, was a memorandum in his handwriting stating, "To-day we made the first bottle, at a cost of \$30,000." (a) This remark has led to the belief that the works was a bottle house, but it was a window-glass factory, making some bottles. The partnership between Craig and O'Hara lasted for seven years, when Major Craig was persuaded by his relatives, who feared financial loss, to withdraw. (b) The works were continued by Colonel O'Hara.

The difficulty and expense connected with this first attempt at glass-making west of the mountains were such as must have discouraged a less determined man than Major Craig, who seems to have had the immediate management of the works, he being in Pittsburgh most of the time, while Colonel O'Hara's other interests called him frequently from Pittsburgh. The men employed as superintendent and blowers did not always prove to be as highly skilled as their own assertions would have indicated, and many of the workmen seem to have been petulant, easily angered, and constantly threatened to leave the works. For some such reason as this, in December, 1798, the works were leased to Eichbaum, Wendt & Co., a firm composed of workmen who do not seem to have been very successful financially. Great trouble was experienced also in obtaining the proper materials. The clay which was found in the neighborhood, and which, as appears from a letter previously quoted, was supposed to be of the proper quality to make pots, proved unfit for use, and clay had to be brought from New Jersey in barrels over the mountains at great expense, and frequently the delays were so great that the furnace had to go out of blast for want of pots. When the clay came the whole force would be put to work making pots, which would be dried hurriedly, and the furnace would be put in blast again with the result that every glass-maker of to day would have anticipated—the pots were lost. In one case, in an 8-pot furnace, three pots were lost at the first melting, and the next day four more, leaving but one in the furnace. Great trouble was also experienced in getting sand, and Major Craig's letters constantly refer to the different localities from which specimens were procured and the success in their use.

The trials and the results obtained at this works are set forth in the following letter, dated August 5, 1803, written by Major Craig to Samuel Hodgson, of Philadelphia:

With respect to our glass manufacturing, the establishment has been attended with greater expense than we had estimated. This has been occasioned partly by very extensive buildings necessarily erected to accommodate a number of people employed in the manufacture, together with their families, and partly by the ignorance of some people in whose skill of that business we reposed too much confidence. Scarcity of some of the materials at the commencement of the manufacturing was also attended with considerable expense. We have, however, by perseverance and attention, brought the manufacture to comparative perfection. During the last blast, which commenced at the beginning of January and continued six months, we made on an average thirty boxes a week of excellent window-glass, beside bottles and other hollow ware to the amount of one-third of the value of the window-glass, 8 by 10 selling at \$13 50, 10 by 12 at \$15, and other sizes in proportion.

In the fall of 1800 the "commissioner of the city of Washington", then just made the seat of government, applied to Craig & O'Hara to make for the public buildings some glass of larger sizes than had ever been produced in this country, but the attempt was unsuccessful. Glass of the size required, to the extent of some 400 square feet, was made "of a transparency tolerably good", but it was too uneven for the purpose, or was spoiled in flattening, and the glass required was obtained from England.

The second glass house built in the vicinity of Pittsburgh, and the third west of the mountains, was that of Denny & Beelen. This factory was situated on the north side of the Ohio river, in that part of Allegheny now known as Manchester, and gave the name to Glass-House riffle on the Ohio. (c) It used wood as fuel, its location being such that coal could not be procured without boating it across the river from the south side of the Monongahela, while wood was easily procurable. The exact date of the erection of this works has not been ascertained, though

a *Military Journal of Major Ebenezer Denny*, p. 487. b *Craig's History of Pittsburgh*, p. 278. c *Major Denny's Journal*, p. 228.

it was probably built in 1800. (a) Window-glass was made, whether crown or blown is not certain, though there is a legend that an attempt was made to manufacture the former. A Frenchman by the name of La Fleur, commonly known as "Falure", was brought to this country to have charge of the works; but they were unsuccessful from the first, and being compelled to cease operations after a short run, the furnace was abandoned, La Fleur entered the employ of Craig & O'Hara, and Beelen (b) gave up the glass business.

As has already been stated, the manufacture of green-glass bottles, or "hollow ware", was carried on in these early glass houses in connection with that of window-glass, the "corner pots" in the window-glass furnaces being used for the manufacture of bottles and flasks. The history of the manufacture of bottles in the West is, therefore, for many years the history of the window-glass works. It was nearly forty years before furnaces for making bottles exclusively were built, and the records of the make of glass at Pittsburgh and of the works in that city as late as 1837 combine window-glass and green glass or bottles as one branch of manufacture. In 1837 there is a record of a "vial works" and a "black-bottle factory", (c) the latter "the only one of the kind in the western country". This factory made wine, porter, and other black or amber bottles, as well as demijohns and carboys. The custom of using the "corner pot" for bottles is now entirely discontinued in this section, bottle manufacture being a distinct branch of the glass industry.

The first attempt to manufacture flint-glass west of the Alleghenies was made in Craig & O'Hara's window-glass furnace in September or October, 1800, by Mr. William Price, of London, who had then lately arrived in this country, and who "had been employed altogether in flint-glass". September 5, 1800, Major Craig wrote Colonel O'Hara that Mr. Price had arrived, and had "offered to show us a specimen of his abilities without charge", and arrangements were made with Eichbaum, Wendt & Co., who were operating the works under lease, to allow him the use of a pot in the furnace and such assistance as he needed to make the experiment. On September 11, 1800, "one hundred pounds of pearlash, refined in the best manner, so that it may be perfectly pure, as it is to be applied in the composition of crystal glass by a man just from London", was ordered from Aaron Aimés, at Funk's tavern, on Franklin road. October 29, 1800, Major Craig sent a specimen of glass made by Mr. Price to Colonel O'Hara, and on November 17, 1800, in a letter to Colonel O'Hara, which he sent by Price, he wrote: "He [Price] has satisfied me, as well as others, that his ability in white-glass manufacturing is equal to his professions."

These extracts from Major Craig's letters leave no doubt but that at this early date an attempt was made to produce flint-glass in Pittsburgh, and, further, that the advisability of building a furnace for its manufacture was seriously considered. Mr. Craig writes that he had hopes that some part of the window-glass house could have been used for the manufacture of flint-glass, but Price told him it could not be done. Major Craig seems to have had some doubt as to obtaining workmen and materials, and also as to whether the business would pay; but Mr. Price was instructed to make an estimate of the articles needed and drafts of buildings, and submit them to Colonel O'Hara. Nothing seems to have come from this attempt at the time. A careful examination of Mr. Craig's letter-books gives no evidence of the prosecution of flint-glass manufacture, and as late as 1803, as will be seen by the letter previously quoted, flint-glass was not made at these works.

There is, however, a statement that should be quoted in this connection, to the effect that in 1802 Colonel O'Hara built an additional furnace at his works and attempted to establish the manufacture of white and flint glass, sending an agent to England to procure the necessary workmen; but this agent is reported to have failed in his mission. (d) I have not been able to verify this statement, and a careful examination of Major Craig's letter-books of 1802 and 1803 gives no evidence of the existence of such a house, though they refer quite at length to Mr. Price's attempt at flint-glass making and to Mr. Edward Ensell, who afterward built a flint-glass works. Nor is any evidence of the existence of such a works found in Cramer's *Almanacks*. In the *Almanack* for 1807 O'Hara's "glass factory" is mentioned, not his factories, as would have been the case were he making both flint- and window-glass, these requiring separate furnaces. (e) In the *Almanack* for 1808, which would give the establishments for 1807, the only glass works mentioned is "1 green-glass works". In the *Almanack* for 1809 Robinson & Ensell's works appears for the first time, and is the only "white-glass" works, and the first one, mentioned.

In Cramer's *Almanack* for 1804, among the amounts for each article made from raw material in Pittsburgh in 1803 are mentioned "jars, decanters, tumblers, blue glass". It has been argued that this proved the existence of a flint-glass house at Pittsburgh, as tumblers and decanters would hardly be made out of green glass; but this supposition

a The memoir prefixed to Major Denny's *Journal*, page 228, states that they were built "about the beginning of the present century". In a letter from Major Craig to Colonel O'Hara, dated March 20, 1801, he writes, referring to this factory: "The Ohio glass works have stopped." These two statements would fix the date at least as early as 1800, and it seems from a number of letters that they were built in that year.

b Beelen was a Belgian, son of the Austrian minister "Baron de Belen Bartholf".—Denny's *Journal*, p. 228. It thus appears that in the early glass works of Pittsburgh were represented the chief glass-making countries of Europe.

c Lyford's *Western Directory*. These houses were on the south side, and have been known in recent years as "Ihmsen's".

d Thurston's *Pittsburgh and Allegheny in the Centennial Year*, p. 128; also, Bishop's *History of American Manufactures*, vol. ii, p. 96.

e A flint-pot could not have been used successfully in the window-glass furnace, as pots for bottle-making were, the method of working precluding this.

is not borne out by the facts, as green-glass tumblers and decanters were quite common at that time. (a) In the *Almanack* for 1804 also appears the oft-quoted statement about glass-cutting "equal to any cut in the states of Europe" which was carried on at Pittsburgh, and it has been claimed that this indicated the presence of a flint-glass house. The amount reported cut, \$500 a year, and the fact that the specimens of Mr. Eichbaum's skill at this early date seem to have been chandeliers, the beautiful clear glass of the prisms of which could hardly have been made in Pittsburgh, indicate that the glass came from east of the mountains, if not from Europe. The evidence I have found is against the existence of such a works. (b)

If such a factory as is mentioned ever existed, it must have been short-lived and of but little note, and cannot be regarded as marking the beginning of the flint-glass industry in Pittsburgh, which dates from 1808. In the fall of 1807 (c) Mr. George Robinson, a carpenter by trade, and Mr. Edward Ensell, an English glass-worker, who had been a manufacturer of both window- and flint-glass at Birmingham, England, and had sold his works and come to this country to better his condition, commenced the erection of a flint-glass works at Pittsburgh, on the bank of the Monongahela, at the foot of Grant street, under the firm name of Robinson & Ensell; but the partners appear to have lacked capital and were unable to finish the works, and the establishment, in an incomplete state, was offered for sale, probably without having made any glass.

In August, 1808, Mr. Thomas Bakewell and his friend, Mr. Page, who were visiting Pittsburgh at the time, were induced to purchase the works on the representation of Mr. Ensell that he thoroughly understood the business. This was the beginning of the firm of Bakewell & Page, that by itself and successors has continued the manufacture of flint-glass to the present, Bakewell, Pears & Co., their direct successors, reporting to the present census. (d)

Mr. Bakewell soon found that the representations made to him as to the skill of the workmen he relied upon were not borne out, and he was forced to rely upon his own good judgment and his diligence in obtaining information about the business. The difficulties he met with would have disheartened a less determined man, and the lack of skill on the part of his workmen and the inferiority of the material interfered at first with his success. His furnace was badly constructed; his workmen were not highly skilled, and would not permit the introduction of apprentices, and his materials were procured from a distance at a time when transportation was difficult and expensive, pearl ash and red lead coming from Philadelphia, and pot-clay from Burlington, New Jersey, all being transported over the mountains in wagons. The sand was obtained near Pittsburgh, but was yellowish, and up to this time had only been used for window- and bottle-glass; the saltpeter from the caves of Kentucky until 1825, when the supply was obtained from Calcutta. These difficulties were in time overcome. Good clay was procured from Holland, and purer materials were discovered; and he rebuilt his furnaces on a better plan, competent workmen being either instructed or brought from Europe, and through his energy and perseverance the works became eminently successful. There can be no doubt that Mr. Bakewell is entitled to the honor of erecting and operating the first successful flint-glass house in the United States.

The furnace built or completed in 1808 held six 20-inch pots. This was replaced in 1810 by a 10-pot furnace, (e) and in 1814 another furnace of the same capacity was added to the works. The establishment was burned down in the great fire of 1845; but was immediately rebuilt. The site is now occupied in part by the Baltimore and Ohio railroad depot, the brick part of the depot being a part of the old warehouse.

The success of Messrs. Bakewell & Page induced others to embark in the business. In 1809 another flint-glass house was built, which produced glass on a limited scale, and in 1810 another company was formed, but failed in a short time. In 1812 another works, making the fourth in four years, was built. (f) It would thus appear that the manufacture of flint-glass increased much more rapidly than that of window-glass, as at that time there was in Pittsburgh only the O'Hara window-glass works, started in 1797.

In 1810 the manufactures of the United States began to attract considerable attention, and for the first time the census returns include a statement of manufactured articles. In this year Mr. Albert Gallatin, then

a These decanters were known as "big-bellied bottles", and were made out of the "corner pots" of the window-glass houses even later than 1837. Mr. Isaac Craig writes me: "I recollect distinctly seeing both tumblers and decanters made of green glass. In old times decanters were used in every house, most commonly by the poorer families, who could not afford cut glass. Whisky was set out to every visitor in these decanters, and before and after every meal. Although of green glass, they were not cut, but ornamented by beads around the neck." These beads were probably pinched on while the glass was still plastic.

b The only evidence I have been able to find that this works ever existed is that contained in Thurston and Bishop. Mr. Thomas Bakewell, who came to Pittsburgh and entered into the glass business in 1808, and who was authority on the early history of glass-making in that city, seems to have had no knowledge of such a works, and speaks of Robinson & Ensell's attempt as the first.

c Jarves, in his *Reminiscences*, who got his information from Mr. Thomas Bakewell, says 1808; but in Cuming's *Tour*, published in Pittsburgh in 1810, is a statement, p. 222, in regard to Pittsburgh, that "an account of the manufacturers and tradesmen was taken in the fall of 1807, the result of which was \* \* \* a glass works for green glass on the opposite side of the Monongahela, another just erected for white glass on the town side of the same river". This latter undoubtedly was the Robinson & Ensell works.

d Since the census year the firm has gone out of existence, after nearly three-quarters of a century of business life.

e See Jarves' *Reminiscences of Glass-making*, to which I am indebted for many of the facts about Mr. Bakewell and his works.

f Jarves' *Reminiscences of Glass-making*, p. 72.



Secretary of the Treasury, made a report to the House of Representatives on our industries, in the course of which he mentioned that "two works, employing together six glass-blowers, had lately been erected at Pittsburgh, and made decanters, tumblers, and every other description of flint-glass of a superior quality".

The Pittsburgh window-glass works is also mentioned, and it is stated that all of this kind of works in the country, with the exception of "that of Pittsburgh", used wood as fuel, the latter using coal. According to the census returns for 1810, there were three glass works in Pittsburgh that year which produced \$62,000 in value. If Gallatin's statement is correct, two of these were flint works, and one manufactured window-glass and green bottles. (a)

Concerning the condition of glass-making in Pittsburgh in 1813 and 1814 Cramer's *Navigator* (b) states:

The manufacture of glass has succeeded as well as the most sanguine had expected. The situation of this place is particularly favorable, notwithstanding some disadvantages in procuring some of the materials. The first was established by Colonel O'Hara about the year 1798. (c) There are two glass works on the opposite side of the Monongahela, erected by Trevor & Ensell, and one in the new town of Birmingham, under the firm of Beltzhoover, Wendt & Co. These, with the three before erected, to wit, O'Hara's, Robinson's, and Bakewell's, will be able to manufacture to the amount of \$160,000 annually. Both flint and green glass are now made here to great perfection. Messrs. Bakewell, Page & Bakewell have lately built another flint-glass works in addition to their former one. There are now in the town and opposite two white and three green glass houses. Glass-cutting is likewise executed in this place not inferior to the best cut-glass in Europe. The furniture of the apothecaries' shops is altogether of home manufacture.

This extract would indicate that some of the flint houses had gone out of existence and capital invested in glass-making was wisely turned to the branches that promised profit.

The number of glass houses after this increased so rapidly that it is impossible to enter into the details of the history of each. In 1819, according to the memorial adopted at a town meeting and sent to Congress, the manufacture of glass in Pittsburgh had rapidly declined since 1815. At the latter date 169 workmen were employed, producing \$235,000 in value of glass annually, while in 1819 the number had fallen to 40, producing but \$35,100, and the statement is made that in flint-glass alone the reduction was \$75,000. (d) In 1820 the census reports the product of "glassware and colored flint" as \$20,000, and of "glass, window and hollow", as \$24,000. In Fayette county, at the same time, there were three establishments making window-glass and hollow ware. In 1826 there were eight window-glass works in western Pennsylvania, producing 27,000 boxes (100 feet) of glass per annum, valued at \$135,000, and, in addition, \$30,000 worth of flint ware was made. In 1831 (e) there were four flint houses, with thirty-two pots, and four window-glass houses at Pittsburgh, four or five at Brownsville, one each at New Geneva, Bridgeport, New Albany, Perrypolis, and Williamsport, making window-glass, and one at the latter place making hollow ware. Mr. Bakewell at this time estimated that the value of glass produced in western Pennsylvania was more than \$500,000 annually. In 1837 there were thirteen factories in Pittsburgh and its immediate vicinity, six flint and the balance window-glass or green hollow ware, making about \$700,000 worth. Among these were the Sligo works of William McCully, established in 1828, and continued at the present day by W. McCully & Co.; the flint-glass works of Curling & Price, known as the Fort Pitt glass works, established in 1830, now carried on by their successors, E. D. Dithridge & Co.; and the window-glass factory of F. Lorenz, now continued by Thomas Wightman & Co. Twenty years afterward, in 1857, there were thirty-three factories at Pittsburgh, of which nine produced flint-glass and twenty-four window, green, and black glass to the value of \$2,631,990, employing 1,982 hands, whose wages were \$910,116, consuming material to the amount of \$2,078,734 40. In 1865 there were fifteen bottle and vial factories, fifteen window-glass factories, and fifteen flint-glass works in Pittsburgh, being forty-five glass houses in all; an increase of 36 per cent. in eight years. These fifteen window-glass works, located immediately at Pittsburgh, had a capacity to make 520,000 boxes of glass in a year, but their average yield was about 400,000 boxes, whose entire value at that time was \$2,600,000. The fifteen green or vial works produced annually about 420,000 gross of vials and bottles, worth, at the then rate, \$2,100,000. The pressure upon these works at that time is best shown by the fact that, although only customary to run them for ten months in the year, yet many of them had run twenty-one months without stopping. The fifteen flint-glass works then in operation at Pittsburgh produced about 4,200 tons of glassware, worth then, in round numbers, \$2,000,000. Their capacity was, however, double the amount produced, or about 8,000 tons. (f)

a Cramer's *Navigator*, published in 1814, states that in 1810 there were two white and one green glass works in Pittsburgh.

b The copy of Cramer's *Navigator* from which this statement is taken bears the date 1814, though the preface was written in 1811. The statement probably refers to 1813 or 1814, as the work was revised and published in several editions.

c This should, of course, be 1797.

d Address of the Philadelphia Society for the Promotion of National Industry, p. 257.

e Report of the New York Tariff Convention, 1831, p. 121.

f Pittsburgh and Allegheny in the Centennial Year. By G. H. Thurston.



## MANUFACTURE OF GLASS.

Below, I give in a tabulated form such statistical information as I have been able to gain as to the glass works of Pittsburgh from 1797:

Date.	WINDOW AND BOTTLE.		WINDOW.		FLINT.		GREEN BOTTLE.		ALL KINDS.	
	Works.	Value.	Works.	Value.	Works.	Value.	Works.	Value.	Works.	Value.
1797.....			1	\$10,000					1	* \$10,000
1800.....			1	10,000					1	* 10,000
1803.....	1	\$12,500							1	12,500
1810.....	1	40,000			2	\$30,000			3	70,000
1812.....									3	62,000
1813.....									5	170,000
1815.....									5	235,000
1817.....	3	130,000			2	110,000			5	240,000
1819.....									5	35,100
1826.....		†135,000				100,000			7	235,000
1831.....	4				2				8	500,000
1837.....			5		6		2		13	728,000
1840.....									10	.....
1850.....			11		8		7		26	.....
1857.....			7		9		9		25	2,631,960
1860.....			5	\$875,520					18	†2,075,143
1865.....			15	2,600,000	15	2,000,000	15	\$2,100,000	45	\$6,700,000
1870.....									32	†5,832,429
1876.....			24		41		11		76	.....
1880.....			12	1,632,687	30	3,215,038	9	820,487	51	5,668,212

\* Estimated.

† 27,000 boxes made.

‡ From the census, and evidently incorrect.

§ Evidently estimated.

|| Number of furnaces, not of works.

At the present census, as will be seen by an examination of the tables, Allegheny county stands first as a glass-making center. Its statistics are as follows:

Kinds of glass.	No. of establishments.	Capital.	No. of furnaces.	No. of pots.	NUMBER OF EMPLOYÉS.				Total wages paid.	Value of materials used.	Total value of product.
					Total.	Males over 16.	Females over 15.	Children and youths.			
Window-glass .....	12	\$1,880,000	23	216	1,133	1,101	.....	32	\$809,842	\$576,638	\$1,032,687
Glassware .....	30	2,744,500	51	496	4,069	2,691	129	1,249	1,500,833	1,180,851	3,215,038
Green glass .....	9	856,500	11	85	851	650	12	189	375,750	332,160	820,487
Total .....	51	5,481,000	85	797	6,053	4,442	141	1,470	2,686,425	2,130,658	5,668,212

It will thus be seen that this county had 24.17 per cent. of the total number of glass establishments of all kinds in the country, 27.62 per cent. of all the capital invested, and produced 26.79 per cent. in value of the products. It had 20.69 per cent. of the number of window-glass establishments, but 37.96 per cent. of the capital invested in window glass, and produced 31½ per cent. of the boxes of glass made, and 32 per cent. of value of product. In flint-glass and glassware Allegheny county had 32.97 per cent. of the number of establishments, 37.04 per cent. of the capital invested, and produced 33.60 per cent. of the value of this kind of glass made. In green glass this county had 16 per cent. of the establishments, 17.50 per cent. of the capital invested, and made 14½ per cent. of the green glass produced. Of the total of the entire country in the three classes named—window, flint, and green—Allegheny county had 24.88 or 25 per cent. of the establishments, 31.76 or 32 per cent. of the capital, and made in value 28 per cent. of all the product.

It should be noted that these calculations do not include plate-glass, of which none is made in this county, nor do they include the works in Fayette and Beaver counties, which have their offices in Pittsburgh.

While the figures show that the proportion of the glass of the United States made in this county is not so great as has been supposed, it indicates that of all the great industries of the country it is the one that produces at Pittsburgh the largest proportion.

## GLASS-MAKING IN MASSACHUSETTS.

The history of the beginning of the manufacture of glass in Massachusetts is involved in some doubt. Bishop, in his *History of American Manufactures*, states that the earliest works was built in a part of what is now the town of Quincy, but in this he is probably mistaken, as the Salem works were undoubtedly the first. He

assigns no date to this Quincy works, but Appleton's *Cyclopædia* gives it as about 1750. This works was, like most of the other early ones in this country, built by Germans, (a) and its site is known to this day as Germantown. Only black bottles were made, some specimens of which still exist, which are of very poor metal and of rude make. The proprietors failed some years before the Revolution, and the house having burned down, it was never rebuilt. (b)

The first glass house in Massachusetts, and the first to which a date can be assigned, was erected in Salem about 1639. In this year Ananias Concklin, Obadiah Holmes, and Lawrence Southwick received two acres of land each "adjoining to their houses", which was granted to them as "glass men", for the purpose of promoting the manufacture of glass. The next year John Concklin, another "glass man", was allotted five acres more bordering the previous grants.

In December, 1641, the general court, for the encouragement of the enterprise, authorized the town of Salem to lend the proprietors £30, which was to be deducted from the next town rate, and the glass men were to repay it, "if the work succeeded, when they were able." (c) The works having been neglected for three years, the Concklins, in 1645, received permission from the court to form a new company to carry on the business. (d) Glass was for a considerable time afterward manufactured at that place, which is mentioned in the *Colonial Records*, in 1661, as the Glass House field. In this, and those which for many years succeeded, it is probable that nothing more was attempted than the manufacture of bottles and other coarse descriptions of glass. (e)

Assuming the date assigned to this works to be correct, it certainly displayed a great deal of enterprise in the infant colony to thus early undertake the manufacture of glass, and, though the products were coarse, they answered the purposes of the colonists. Window-glass could be imported from England of a much better quality than could be made, but bottles were so bulky and so liable to breakage that they could be made to advantage in competition with the works of the mother country.

The history of the glass works of New England is involved in doubt for some years after this, but it is probable that a works was built at Boston just prior to the Revolution, as Lord Sheffield, writing at the close of the war, says: "A considerable glass manufacture at Boston failed there several years ago." In December, 1752, the general court passed an act granting Isaac O. Winslow and others the sole privilege of making glass in the province. It is probable that this works was established at Boston, and that it was this failure to which Lord Sheffield refers. However this may be, Boston again began the manufacture of glass shortly after the Revolution, and this time with great and long-continued success. This new enterprise, the Boston Crown Glass Company, which was the first really successful glass works in the country, was greatly encouraged by the very liberal action of the state. In July, 1787, Messrs. Whalley, Hunnewell, and others received from the legislature a charter conferring upon them the exclusive right to manufacture glass in Massachusetts for fifteen years, and a fine of £500 was attached to any infringement of this right. The capital stock was exempted from all taxes, and the workmen from all military duties. Jarves also states that to counteract the effect of the bounty paid by England on the exportation of glass from that kingdom the state paid the proprietors of this works a bounty on every table of glass made. A pyramidal factory of brick was erected on a large scale at the foot of Essex street; but being found ill-adapted to the purpose, it was afterward taken down and a wooden one, lined with brick, differently constructed, was put up in its place, its dimensions being 100 feet in length by 60 in width. On account of difficulties in procuring workmen and other embarrassments operations were not fully commenced until November, 1792. (f) The corporation commenced with the manufacture of crown window-glass, which was of a quality equal or superior to any imported. Materials were found to be abundant, and some six years later they produced about 900 sheets per week, worth \$1 75 per sheet, or \$82,000 per annum. (g)

This works was incorporated as the Boston Crown Glass Company in 1809. Regarding the success of this company Mr. Jarves says:

The state bounty had the effect to encourage the proprietors and sustain their efforts, so that by perseverance many difficulties were overcome and a well-earned reputation supported for the strength and clearness of their glass; a glass superior to the imported, and well known throughout the United States as "Boston window-glass". This reputation they steadily sustained, until they made glass in their new works at South Boston in the year 1822.

The early success of this works led to the establishment of others in various parts of the country, and many of the workmen of the Essex-street house were enticed away by flattering offers. In 1811 the proprietors of the Essex-street works erected large and improved works on the shore at South Boston, and to supply the workmen enticed away, as also to meet the wants of their factory, an agent was sent to England to procure a set of glass-workers. By the time they reached this country the war with England broke out, and the enterprise was defeated;

a It is an interesting fact that some or all of the workers in the first glass houses of Virginia, Maryland, Pennsylvania, and New Hampshire were Germans.

b See Jarves' *Reminiscences of Glass Making*, p. 53. Also *Mass. History Col.*, vol. iii, p. 276.

c Felt's *Annals of Salem*.

d *Colonial Records*, vol. i, 344; ii, 137.

e See Bishop's *History of American Manufactures*, vol. i, pp. 233, 234.

f Mr. Jarves says in 1803, upon the arrival of a German by the name of Lint (probably Lindt).

g See Bishop's *History of American Manufactures*, vol. i, p. 241.

for it became difficult to procure fuel and the various means for carrying on the Essex-street works. After the war operations were resumed and continued until 1826, when from bad management the company failed.

In 1802 glass works were established at Middlesex village, then in the town of Chelmsford, but now a part of Lowell, by Hunnewell & Gore, of Boston. Window-glass was the chief product, though some other glass was made. Allen's *History of Chelmsford*, published in 1820, states:

On the east bank of Middlesex canal, a distance of 200 rods from Merrimack river, a large building, 124 feet long and 62 feet wide, with necessary appendages for manufacture of window-glass, was erected in 1802.

Near it is a two-storied house, handsomely finished, designed for the residence of the overseer, and around it, at convenient distances, a number of smaller houses for the accommodation of the workmen and their families.

There are appertaining to this manufactory about 20 families, consisting of 40 men, 20 women, and 40 children—100 in all. It is now in a flourishing state. About 330,000 feet of window-glass are annually made, or 3,300 boxes of 100 feet each, which, at \$13 per box, will amount to \$42,900.

The situation is very favorable for transportation to Boston, and those raw materials from thence which it would be expensive to convey by land. A ready and cheap supply of wood is also easily obtained, of which it is estimated that about 2,000 cords are annually consumed in the manufactory and houses attached to it.

The manufactory consists of two furnaces, three flattening ovens, two tempering ovens, six ovens for drying wood, cutting, mixing, and pot rooms, a kiln for burning brick, a mill-house, and sand-house.

The proprietors failed about 1827 or 1828; the works were also burned about this time. In 1828 a corporation was formed and the works rebuilt, but it is uncertain if glass was made before 1829. In 1839 the works were abandoned and moved to Suncook village, Pembroke, New Hampshire. The process of manufacture at this works is thus described: (a)

The process was to mix Morris river (New Jersey) or Massabesic lake (New Hampshire) sand with lime, sal-soda, black and white salts, etc.; no sand was ever procured for the purpose in this region. Ten large pots were heated from one furnace, each pot making about 500 surface feet of glass per "melt", and there were on an average about twenty-five "melts" per month, running nine months of the year. The glass was first blown in cylindrical shape, like a long piece of stove-pipe, then cut along one side lengthwise and flattened.

Various other attempts have been made in eastern Massachusetts to establish the manufacture of window-glass, the details of which I have not been able to ascertain. In 1860 a large establishment, the Boston crystal glass works, was erected at South Boston for the manufacture of sheet window-glass. This was followed by several smaller ones, but they all failed to make glass at a profit, and were abandoned. As an illustration of the losses frequently met with in these manufacturing experiments, it may be stated that the plant of this Boston crystal glass works, which cost about \$186,000, after lying idle for fifteen years, was sold in 1881 for \$60,000 to the Walworth Tube Manufacturing Company. All the window-glass works in this section have been abandoned, and in the census year the only one in operation in the state was in the western part, in Berkshire county.

Through the kindness of Mr. A. T. Servin, of Lenox Furnace, who has been closely identified with the glass industry of that section, I am enabled to give some details of the attempts to establish its manufacture in western Massachusetts. In 1812 a window-glass factory was started at Cheshire, probably the first attempt at the manufacture of glass away from the seaboard, and about the same time another was built in the near town of Chester Factory. These were brought into existence by the war of 1812, and owing to the superior quality of the sand were located at this place. Both of these ran but a short time. In 1850-'51 a window-glass factory was started at Cheshire, ran about two years, and was changed to a plate-glass factory. It has since been used for window-glass, but is now abandoned. In 1853 a factory was started at Berkshire. This is still in successful operation, and is the only works that made window-glass in New England in the census year. In 1853 another factory was started at Lenox Furnace, but this was changed to plate-glass; and in 1869 still another works was built at this place, which ran for about two years, but is now abandoned.

The beginning of the manufacture of flint-glass in Massachusetts was an outgrowth of the Essex-street factory. Among the workmen brought to this country to operate this works were a number who were not only skilled window-glass blowers, but were flint-glass workers as well. When the window-glass works were compelled to suspend operations in part, owing to the difficulty of procuring materials during the war of 1812, a number of blowers were thrown out of occupation. Among these was Mr. Thomas Caines, who was still living when Mr. Jarves wrote his *Reminiscences*. Mr. Caines, who was not only a skilled blower, but an admirable manager, and was also well acquainted with the art of mixing glass and the proportions employed, prevailed upon the proprietors of the window-glass works to build a small six-pot flint furnace in a part of their unoccupied works at South Boston. This establishment found full employment during the war of 1812. It, however, was compelled to cease operations, and though several attempts were made to operate it between 1820 and 1840 they were unsuccessful. About the same time that this South Boston factory was built the Porcelain and Glass Manufacturing Company was incorporated and built a flint-glass house at East Cambridge. The furnace was a small six-pot one, and workmen were brought from abroad to work it; but it proved a failure. In 1815 some workmen left the South Boston factory, leased this furnace at East Cambridge, and commenced the manufacture of flint-glass under the firm name of Emmet, Fisher & Flowers; but want of harmony among the members of the firm led to a dissolution, and in 1817 the Porcelain Company disposed of their works at auction. These were bought by the New

England Glass Company, which was incorporated in 1817, and from these works has been produced glass the equal of that made in the best English flint houses. This works, when it first started, had a small six-pot furnace, each pot holding about 600 pounds of batch. Some forty hands were employed, and the yearly product was about \$40,000. Bishop, in speaking of these works in 1818, which he calls "one of the most extensive flint-glass manufactories in the country", says:

Two flint-glass furnaces and twenty-four glass-cutting mills, operated by steam, and a red-lead furnace, capable of making two tons of red lead per week, enabled them to produce every variety of fine, plain, mold, and the richest cut glass, as Grecian lamps, chandeliers for churches, vases, antique and transparent lamps, etc., for domestic supply and exportation to the West Indies and South America. Virginia coal, New Orleans lead, Delaware sand, and other native materials were used. The capital was about \$80,000, and the annual product \$65,000.

In 1823 it is stated that 22,400 pounds of glass vessels per week were made, many of which are beautifully cut, and were sent into Boston and other places for sale. Writing of these works in 1865, Mr. Jarves states that five furnaces were run, averaging ten pots each, with a capacity of 2,000 pounds to each pot. Five hundred hands were employed, and the yearly product was \$500,000. This works is still in existence, but is leased to Mr. W. L. Libby, who runs only a portion of it. Its reputation for the excellent quality of its glass is still very high.

In 1825 ground was broken for a flint-glass works at Sandwich, and in three months they commenced blowing glass. These works also commenced in a small way with an eight-pot furnace, the weekly melts being some 7,000 pounds; but at the time Mr. Jarves wrote his *Reminiscences* the weekly melts had been increased to about 100,000 pounds, and the one furnace, with eight pots, to four with forty pots.

In 1865 Mr. Jarves states that two flint-glass establishments were in operation in East Cambridge, three in South Boston, and one in Sandwich. At the present time there are six glassware establishments in Massachusetts, of which one was entirely idle and virtually out of existence and another idle in part.

Some of the most interesting chapters in the history of glass in Massachusetts are those recording the successes and defeats connected with the manufacture of plate-glass. These are given in detail in that part of this chapter treating of plate-glass. Here it is only needful to say that these attempts began at Cheshire in 1852-1853. The works was changed from window-glass to plate-glass, run for about two months, and was then moved to Brooklyn, New York. The second effort was at Lenox Furnace. These works, after passing the vicissitudes narrated elsewhere, are still in existence.

Though at one time Massachusetts was in the foremost rank of glass-producing states, the lack of fuel has caused it to fall in the rear as to amount of product. In some lines as to quality, however, it is still unsurpassed.

#### GLASS-MAKING IN NEW HAMPSHIRE.

Glass-making in New Hampshire dates from near the close of the revolutionary war. In May, 1780, Mr. Robert Hewes, of Boston, began the erection of a glass works in the town of Temple, and in the autumn or early winter he started his fires. At this time glass was in good demand in the rebellious colonies. England, of course, prohibited all exportation from her ports, and the severity of the blockade prevented the glass of other countries from reaching this in any quantities. Indeed, the holds of the blockade runners would scarcely find space for glass, when powder and shot were more in demand.

Mr. Hewes, who had been left by his father quite a fortune, determined to undertake the manufacture of glass. Having secured a number of German Hessians and Waldeckers, who were skilled glass-workers in their own country and had formed part of the mercenaries sent to this country with the British army, and who had deserted from it, he started this Temple works; but the building was hardly completed when it was burned down. This was a serious blow, but to prevent the abandonment of the enterprise the people of Temple came to Mr. Hewes' assistance, and the works were reconstructed. Then frost shattered the furnaces so that they would not stand the fire, and they gave way at the first melt. (a)

To add to his difficulties as a result of these delays and loss his capital was seriously impaired and money was needed to continue the enterprise; but the people of Temple had no money to lend, and did not choose to invest it if they had. Mr. Hewes petitioned aid from the state, asking "freedom from taxation on his buildings", exemption of taxes for his men, and the granting of a bounty upon the glass produced. January 2, 1781, the house of representatives of New Hampshire voted to receive and accept Mr. Hewes' petition, but postponed the paying of bounty till good window-glass could be successfully produced.

The persistence of Mr. Hewes is best illustrated by the following petition made to the selectmen of Temple in the winter of 1781, written from Boston:

GENTLEMEN: After due respects, hoping these will find yourselves and families well, they are to inform, that, being almost discouraged by the misfortunes I have met with & the little spirit of the People to encourage me, I am almost determined to drop all thoughts of prosecuting the Glass-Manufactory in Temple, for why should I strive to introduce a Manufactory to benefit a people that has not spirit enough to subscribe a trifle to encourage it, when I have met with a misfortune—for if the Business ever comes to perfection it will be a greater service to the country than it possibly can be to me, even if I make my fortune? But, Gentlemen, it was not money only, that

a These facts concerning Mr. Hewes' enterprise are condensed from a paper on "Glass-making in the Merrimaek Basin", published in *Contributions of Old Residents' Historical Association*, Lowell, Massachusetts, vol. ii, No. 2.

induced me, but it was because I was satisfied I could do it, & in so doing serve my country most essentially—more especially your Town. You will do well, Gentlemen, to consider this is not a thing for a moment, but it is laying a foundation for the good of Posterity; for certain *I am* if my Glass-works are brought to perfection, they will soon be as universal as the Iron works, or many others; as I said to Esquire Blood the other day, “that the Glass-makers should be employed, if it were only to steal their art.”

I think the Town of Temple, as a Town, will be highly culpable if they let this matter slip without a struggle. But it is not for me to point out the advantage you are all sensible of.

What I have to say is what will your Town do to encourage the matter? I shall have to send 60 miles for stones to build my melting furnace, which will take eight teams, & then all the other furnaces are *to be rebuilt*; but all this while, the Glass-makers and families are to be supported, which will be a costly affair.

Your court will make a Lottery, I suppose, but that will be a thing of Time. Can I be credited for one or two Carcasses of Beef, till the Lottery is drawn, or what way can you think of to help me till the works are set a going?

I should be glad to know your opinion of the matter as soon as possible, so that I may know what to determine.

From Your Friend and Humble Servant,

ROBERT HEWES.

P. S.—Mr. Ashley will wait upon you with this and receive your answer, and transmit it to me as soon as possible.

R. H.

P. S.—If I could be properly encouraged, I would come up in the *Spring* and work at it myself till it comes to perfection.

MARCH 5, 1871.—The Town voted to advance upon a loan to Mr. Hewes £3000, with good security, to be assessed in two months, and collected as soon as may be.

On the same day, March 5, Mr. Hewes' agent at the glass house wrote to the selectmen “requesting provisions”.

March 11, Mr. Hewes writes to the selectmen from Boston, declining the loan of £3,000, if security is required; states he will not assume any further risk or responsibility; that ten times that sum could be secured in Boston if he wanted it, but that he had determined to recede immediately, and proposed to sell his interest in the works at a low price; had resolved to do nothing further except bring down the workmen, if nobody appears to purchase the houses and tools.

March 24, in a letter from Boston, Mr. Hewes proposes to the selectmen that he be supplied money on a loan, on the strength of the lottery, for which he seems to have petitioned the general court of New Hampshire, and requests that his glass-blowers be furnished with supplies for subsistence.

It was not till March 30, 1781, that the lottery act was passed, giving leave to raise £2,000, new emission, for the Temple glass works, and appointing three men to conduct the lottery and report their proceedings and account to the general court within one year. A fac-simile of the lottery tickets may be found on page 171 of the *History of Temple*.

The tickets would not sell, and I have no statement what their prize was to be. I infer the great obstacle to the success of the Lottery to have been want of faith in the glass works, and as a result Mr. Hewes abandoned the enterprise. The works made both window-glass and glassware, and some of its products, among them a glass plate, are preserved in Harvard University.

There is no record of any further attempt to make glass in New Hampshire until 1814, when by an act of the legislature, passed on June 24 of that year, the New Hampshire glass factory was incorporated at Keene. This works made only cylinder window-glass, and the census of 1820 reports it as having a capital of \$25,000, paying out \$11,400 for materials, \$10,000 for wages, \$500 for contingent expenses, employing twenty men and five youths, and producing \$30,000 worth of window-glass from 1,825 bushels of sand, 200 barrels of lime, 547 bushels of salt, and 36 tons of potash. In the hands of its original owner the enterprise was not successful, and passed under the control of other parties, who, in turn, disposed of it to others. From 1847 to 1851 the works were operated by J. D. Collony, when they were finally abandoned, no part of them remaining.

In 1817 a factory was started in the same town (*a*) for the manufacture of “black and flint bottles” by Justin Perry. This was operated until 1848, when it ceased work, for the same reason that the window factory was abandoned—the high price of fuel.

In 1840 Mr. William Parker, who had been operating a window-glass works at Middlesex village, Massachusetts, then a part of Chelmsford, but since annexed to Lowell, removed it to Pembroke, New Hampshire, where he built a brick glass house for window-glass. The motive for moving the works from Chelmsford to Pembroke was the reduced cost of supporting the workmen, ease of obtaining cheap fuel, and close proximity to an abundant supply of sand at Massabesic pond, in Chester, now Manchester. These works were carried on from 1839 to 1850, but were by no means a success in their new location, the expected supply of suitable sand proving a delusion, that from Massabesic producing glass of so dark a color, by reason of iron, that it was unsalable, and sand from the Maurice river, New Jersey, was the only resort, with increased cost for transportation. The revision of the tariff in 1845 brought another disaster, the duty on imported glass being made so low that the country was supplied with European glass at less price than the cost of production here. In 1848 the manufacture of sheet window-glass was abandoned and that of crown glass undertaken, but with no success, and in 1850 its manufacture was abandoned.

<sup>a</sup> This is the account I have received from Mr. William S. Briggs, of Keene. Bishop, in his *History of American Manufactures*, published in 1868, vol. ii, p. 206, speaking of the year 1814, says: “A glass manufactory was this year incorporated in Keene, New Hampshire, where it is still (1868) a principal business.” This is probably an error.

In March, 1866, a glass house for the manufacture of bottles was built at South Lyndeborough, New Hampshire. This works is still in existence. Its characteristics and product will be found in the tables of this report.

## GLASS-MAKING IN NEW YORK.

According to Bishop's *History of American Manufactures*, among the early settlers on Manhattan Island was a glass-maker, Jan Smeedes, who is supposed to have been among the first to receive an allotment of land on the present South William street, between Wall and Pearl. He probably carried on the business of glass-making on the east side of the street, just north of Hanover square. This street formerly bore within the above limits the name of "the Glass-maker's street", and afterward Smee street, from its original occupant. Of the history of his works no account has been found. In addition to this early works at the southern end of the island there seems to have been a glass house located between Eighth and Eleventh avenues and north of Thirty-fourth street, as on De Witt's farm map of New York about 1732 there is an estate called "the glass-house farm". The first of these works must have been built early in the seventeenth century, at least during the Dutch occupation of the island, which ended in 1664. It would thus appear that New York, equally with Virginia, Pennsylvania, and Massachusetts, counted glass-making among its very earliest industries, dating not much after the first colonization.

From this time for nearly a hundred years no records of the existence of any glass works have been found; but no doubt there were some factories in operation at various points and at various times in this state, as well as in other states, though glass-making flourished but poorly in these early times. In 1754 a glass works was erected by a Dutch gentleman by the name of Bamber in Brooklyn, probably the first in Kings county, which now ranks second as a glass-producing center in the United States. The Historical Society of that city have in their cabinet a glass bottle having blown on it the name of Mr. Bamber and the date 1754, (a) "the first one," so the record reads, "manufactured at the glass works started in 1754 on the site of the present glass works on State street. This enterprise, we are informed, was brought to an untimely end for want of sand; that is, the right kind of sand." From this statement regarding the sand Mr. Jarves is led to believe that the bottle must have been of flint-glass, and the works a flint-glass works, as sand suitable for green or black glass abounds on the shore near its location. This, however, would not be conclusive evidence of the fact that they were flint works, as we have no doubt that in those days, as at the present time, reasons which are not at all the correct ones were frequently given for the failure of manufacturing establishments.

Governor Moore, in a letter to the Lords of Trade and Plantations, dated Fort George, New York, January 12, 1767, says:

The Master of a Glass House, which was set up here a few years ago, now Bankrupt, assured me that his ruin was owing to no other cause than being deserted in this manner by his servants, which he had imported at great expence; and that many others had suffered and been reduced as he was by the same kind of misfortune. (b)

To what works Governor Moore referred does not appear.

From this time until 1786 I have not been able to find any other record, when, as the evils of large importations began to be seen and felt, and the advantage of establishing domestic industry became impressed upon the minds of the inhabitants of this country, efforts were made in New York, as in the other colonies, to re-establish the manufacture of glass. In April, 1786, specimens of white glass made at the glass house that had lately been erected in Albany were presented to the American Philosophical Society. Mr. Elkanah Watson, in his *Reminiscences of Albany*, published in 1788, mentions a visit to the new glass house, erected by John De Neufville at a place about eight miles from Albany. Mr. De Neufville, who was a Dutch gentleman, and had been active on behalf of the American colonies during the revolutionary war, having sacrificed in their behalf nearly the whole of a fortune of a half-million sterling, invested the small amount remaining in what Mr. Watson terms the "hopeless enterprise" of a glass house. (c) In January, 1785, Leonard De Neufville and his associates, the proprietors of a glass factory situated at Dovesborough, in the midst of a well-wooded pine forest, described as 10 miles from Albany, and which was probably the same works as that referred to by Mr. Watson in his memoirs, applied to the legislature for aid in their undertaking, urging as a reason for this assistance that £30,000 were sent abroad annually for glass. (d) They also stated that they were able to manufacture any size superior to English glass. This expression would lead to the belief that the works was a window-glass works. In 1793 the legislature of New York voted a loan of £3,000 for eight years to the proprietors, three years without interest and five years at 5 per cent; but by this time the works had passed out of the possession of the De Neufville family. In *The Appolo*, published at Boston, under date of September 28, 1792, appears the following regarding this works:

We learn from Albany that the glass works erected several years ago within a few miles of that city, and which has been deserted ever since for want of cash, is now owned by Messrs. McCallen, McGregor & Co., who have completely repaired it, supplied it with every material, and are now manufacturing and advertising for sale window-glass of every dimension. They want a good flint-glass maker. As this manufactory must be of great public utility, it is to be presumed they will receive the greatest encouragement from all (American) glass dealers: (e)

a Stiles *History of Brooklyn*, vol. i, page 309.

d See Munsell's *Annals of Albany*, vol. ii, p. 205.

b New York Colonial Documents, vii, page 889.

e Quoted from *The Appolo*, p. 416, by *The Historical Magazine*, 2d S., vii, p. 16.

c See Munsell's *Annals of Albany*, vol. x, pp. 219, 220.



The new proprietors, McCallen, McGregor & Co., offered in 1793 a reward of \$50 for the discovery of a bank of sand suitable for their use situated within ten miles of their works. In 1796, for the purpose of consolidating and extending the operations, a village ten miles west of Albany was laid out and named Hamilton, in compliment to Alexander Hamilton, and in the spring of 1797 the Hamilton Manufacturing Company was chartered by the state, and the company and its workmen exempted from taxes for five years. This works was one of the most extensive glass works at that time in the United States. Beside other enterprises in other lines of industry, they had two glass houses, with three large furnaces, employing about thirteen glass-blowers, and making an average of 20,000 feet of window-glass per month, beside bottles and flint-glass. It is stated that they substituted kelp for pearlash in the manufacture of glass. Their glass, however, was in good repute, and the business was actively carried on for some years. Munsell states that this works suspended in 1815 for want of fuel. (a)

The next factory of which I have been able to find any record is the Rensselaer glass factory, which was incorporated by the legislature of the state March 21, 1806. In 1809 two more glass works—the Madison and the Woodstock Glass Manufacturing Associations—were also chartered, but I have not been able to find any details of either. In the census for 1810, however, four glass works are reported: one in Albany county, two in Rensselaer, and one in Ontario. These works made that year 3,805,000 square feet of glass, which was valued by the marshals at 16 cents per square foot. In 1810 or 1811, according to Mr. Jarves, a company was formed in Utica for the manufacture of window-glass, and quite a number of workmen from the Essex-street works (Boston, Massachusetts) were induced to leave their employment and break their indentures by the offer of increased wages, but while they were on their way to the New York house, and just before they reached the state line, they, with the agent of the Utica works, were arrested, brought back, and an expensive lawsuit resulted. Mr. Jarves states that the latter works were abandoned and never revived. In the private journal of De Witt Clinton for the year 1810, when, as one of the commissioners of the state of New York, he examined the country between the lakes and the waters of the Hudson, appear several references to the glass works of the state, and under date of Geneva, August 9, 1810, he writes:

A glass manufactory is erecting about two miles from the village. It was incorporated last winter, and a little village is already rising up around it.

One week later he writes:

We entered the town of Vernon, in which three glass houses are in contemplation; one has been in operation some time. It is rather to be regretted that this business is overdone. Beside the glass introduced from Pittsburgh, and from a glass house in Pennsylvania, on the borders of Orange county, and the glass imported from Europe, there are ten manufactories in the state already, or about to be established; one in Guiderland, Albany county, one in Rensselaer county, three in Vernon, Oneida county, one in Utica, Oneida county, one in Rome, Oneida county, one in Petersborough, Madison county, and one in Woodstock, Ulster county.

In 1818 the manufacture of window-glass was begun at Sand Lake, in Rensselaer county, by Messrs. Crandall & Fox. This locality was selected on account of its abounding both in sand and in fuel, but a few years' trial convinced the proprietors that the place was ill-chosen, and the location was abandoned. (b) In 1845 Mr. Samuel H. Fox, a son of one of the proprietors of the Sand Lake works, built a factory at Durhamville, which was in existence in the census year. The *Utica Observer*, in an article published some months since, claimed for Mr. S. H. Fox, one of the proprietors of this works, and one of the oldest living glass-makers in the country, that he was the first in the country to introduce soda-ash into the manufacture of glass, as he was the first in the state to utilize coal in the furnaces and to introduce wheel ovens.

From the census of 1820 it appears that there were two window-glass factories in Madison county of this state, each containing two furnaces, with ten pots each. In Oneida county there was one cylinder window-glass factory in operation, and one crown-glass factory idle. In Ulster county there were two window-glass factories, manufacturing 800,000 square feet a year; but of these works I have not been able to find any further details. In 1820 some workmen left the New England glass works at Cambridgeport, Massachusetts, and built a factory in New York city, the business being conducted under the firm name of Fisher & Gillerland; but in 1823 the partnership was dissolved, and Mr. Gillerland built a works in Brooklyn. In 1823 there was a manufactory of glass globes at Albany "on a scale which promised to supply the United States with the article". At the tariff convention which was held in New York in 1831 three flint-glass factories, with twenty-two pots, were reported in existence in New York and vicinity, and two cylinder window-glass factories: one at Geneva, and the other at Hamilton; but of these, except the fact of their existence, no details were given. In 1832 the Redford Crown Glass Company was incorporated and began the manufacture of crown glass in Clinton county, making a very good quality until 1841, when it failed. In 1846 crown glass was again made at these works. Of the establishment and history of the later glass works no record at all has been procured.

#### GLASS-MAKING IN CONNECTICUT.

Information regarding the early history of glass-making in Connecticut is exceedingly meager. It appears, however, that in 1747 a patent was granted by the legislature to Thomas Darling for the exclusive privilege of making glass for twenty years. This act appears to have become void because of the patentee's failing to fulfill its

<sup>a</sup> See Munsell's *Annals of Albany*.

<sup>b</sup> This is Mr. Jarves' statement of the close of the works. It would appear, however, from a newspaper paragraph regarding the Durhamville works, that the Sand Lake factory was in existence until 1852, when it was burned down.

conditions, and at various times after this special grants were made to others to introduce its manufacture; but how successful these were I have not been able to find out. It seems that a few years after the organization of the Essex-street factory in Boston, which was built in 1787, a glass house was in operation in Hartford, Connecticut, and from a reference in Washington's diary (1789) it would appear that glass was made in New Haven. In the census of 1820 two glass works are reported in existence in Hartford county, Connecticut, producing \$27,360 worth of glass annually. Bottle-glass is also reported as made in Hartford county at the census of 1820 to the extent of \$3,350 annually. At the tariff convention held in New York in 1831 a window-glass works is reported as in operation at Wellington. In the census of 1840 two establishments are reported in Tolland county, making \$32,000 worth annually; one of these was probably the Wellington works. In 1850 but one establishment is reported; in 1860 two establishments in Windham county; and in 1870 three establishments. Of these works I have been able to get no information other than the fact of their existence. At the census of 1880 but one establishment was in existence in the state, the flint-glass works at Meriden.

#### GLASS-MAKING IN MARYLAND.

On May 26, 1790, Mr. John Frederick Amelung presented a petition to the national House of Representatives, asking that the patronage of the government be extended to his glass manufactory at New Bremen, in Maryland. This is no doubt the works to which Mr. Carroll, of that state, alluded in his speech of April 17, 1789, when he moved that a duty be placed on window and other glass, with the exception of black quart bottles. Mr. Carroll's reason for his motion was that the manufacture of window-glass had been begun in Maryland, and had been attended with considerable success, and he believed that with small encouragement it would be permanently established. Mr. Carroll's motion was successful, and in the first tariff law passed under the present Constitution a duty of 10 per cent. *ad valorem* was levied on the kinds of glass mentioned. The patronage that Mr. Amelung desired was a loan from Congress. The investigation and discussion that followed is memorable as raising, and for the time being deciding, the policy of Congress relative to bounties and protection. The committee to which was referred Mr. Amelung's petition for "patronage" reported June 30, 1790, authorizing the Secretary of the Treasury of the United States to make him a loan, not exceeding \$8,000, Mr. Amelung giving satisfactory security for the reimbursement of the same within a certain number of years. In the debate which followed the presentation of this resolution a history of this gentleman's exertions in endeavoring to establish an American glass manufactory was given by Mr. Carroll. He commenced in 1775, brought into the country upward of 200 persons, mostly glass-workers, and had expended at that time over £20,000 in the undertaking. Owing to a variety of accidents, and particularly to the extraordinary rise in the price of grain, he now found himself "greatly embarrassed in prosecuting the business; but stated if he could be so far patronized by the government as to be favored with a loan of \$15,000 or \$20,000 it would afford him such relief as would enable him to surmount every difficulty".

Congress, however, did not look upon this appeal favorably. Some of the members doubted the constitutional power of Congress to loan money in this way; others objected to it on account of the precedent it would establish, while others urged that the encouragement and assistance could be asked for with more propriety from the state government. Mr. Boudinot gave an account of the manufactory, and said: "I have seen the glass made in it, which is superior to any ever produced in America." He contended that Congress had a right by the Constitution to loan the money, and cited several instances in point. He enlarged on the merits of the petitioner "in embarking such large property to prosecute a business of so general utility", and pointed out the consequences which would result from a "failure of this application, which would be greatly injurious to the petitioner and to the public". The report, however, was negatived, and the question between bounties and protection was virtually decided by this debate. In 1794 Mr. Amelung presented a petition for an increase of duties, and in this he was joined by others, among them Thomas Whalley and his associates, of Boston, Massachusetts. Mr. Amelung's works appears to have been originally built on Tuscarora creek, four miles above Fredericktown, and were known as the Etna glass works. Window-glass and wine-bottles were made, and it is probable that some of the workmen from this factory were among those that crossed the mountain to New Geneva and aided Albert Gallatin to establish their manufacture on the Monongahela. The works of Amelung were moved to Baltimore "in 1788, and located on the south side of the basin", and an account of Baltimore, published some years since, declares "they still continue". In Lossing's *Home of Washington* (pages 204-205) is an extract from a letter of a gentleman of Cincinnati describing the presentation to Washington by Mr. Amelung of two flint goblets bearing the general's coat-of-arms. Amelung's ventures did not succeed, and it is possible that he crossed the mountains to Pittsburgh with some of his glass-workers. (a)

In 1790, according to Howard, a factory known as the "Baltimore glass works" was established on Federal Hill. Colonel Scharf, in his *Chronicles of Baltimore*, page 236, makes the date 1799. This was the window-glass works at present operated by Baker Brothers & Co., and still known by the same name. This firm also have flint and green glass houses. Concerning the latter, they write me that it was originally established in 1790, though the present works date only from 1852; the flint works date from 1873.

a Cuming's Journal, page 66, speaks of a Mr. Amelung, a glass-worker, at Pittsburgh.

The census of 1810 gives statements of three glass works in this state, two in Frederick county, at which 40,000 square feet of window-glass and 7,000 bottles were made, and one in Baltimore county, at which 500,000 square feet of window-glass were produced.

The census of 1820 reports a glass works in Alleghany county, at which both window-glass and hollow ware were made, and gives the date of the establishment of the works as 1817. The value of the products is given as \$30,000, thirty men and eight children and youths being employed. The same census gives statistics of a window-glass works in Baltimore county that had been in operation twenty years, and was producing 3,400 boxes annually, valued at from \$8 to \$10 a box.

At the tariff convention held in New York in October, 1831, two flint-glass furnaces, with twelve pots, were reported in operation in Baltimore; also one cylinder window-glass factory in Baltimore and one in Cumberland; but no details are given of the same.

The works other than the above at present in existence in Maryland are of comparatively recent date, and are all situated in Baltimore, with the exception of a glassware factory building at Cumberland.

#### GLASS-MAKING IN NEW JERSEY. (a)

The first glass factory in New Jersey was located about 2½ miles from Allowaystown, Salem county, and was built some time from 1760 to 1765 by a German named Wistar, who brought a company of workmen with him from Germany. He carried on the works a few years, and failed about the outbreak of the revolutionary war, and upon his failure, in 1775, the workmen went to what is now known as Glassborough, Gloucester county. Two objects led to the selection of this place as a site for works: it was so far inland that the operations were not interfered with by the armies, and it was a yellow-pine country, which wood was better for melting glass than the oak of Allowaystown. Mr. Bodine is of the opinion that "the principal kind of glass made was hollow ware or bottles; but from some recollections of an old man that descended from and knew some of the old Glassborough settlers and heard them talk when he was a boy, I think part of them, if not all, could make both bottles and window-glass, such as was used in those days".

The blowers at these works also made the pots, cut the glass into lights, and packed the same. In the scheme of division of labor in more modern works each of these operations is a separate branch of work. At this works the bottles were made without molds, and crown-glass was made. Mr. Bodine says:

I knew some blowers, when I was a small boy, that were then old men, and could make both bottles and window-glass. I have been unable to fix a time when window-glass commenced to be made in cylinder form. I find that about 1812 or 1813 a crown-glass (window-lights) factory was started up the Delaware river, 10 miles from Belvidere, at a place called Columbia, in what was then Sussex county, now being Warren county. This factory run until 1833, when it ceased operations. I personally know of cylinder window-glass being made in 1827 or 1828 at Millville. About the time of starting the Columbia works a factory was started at a place called Clementon, now in Camden county, where bottles were made part of the time and window-glass the balance. My informant worked at Clementon in 1814 as an apprentice, learning to blow.

About the years 1814 and 1815 there were factories started at Port Elizabeth, Cumberland county, and at Malaga, Gloucester county. Both of these were run as window-glass factories, and in 1816 to 1819 Tuckahoe and Hammonton were started and manufactured principally window-glass.

The next works was Millville, started in about 1822. For some years after this no new works were started, until 1827, when between that date and 1832 Waterford, Jackson, old Brooklyn, and Winston were built. These last-mentioned places were in what was Gloucester, now Camden county. The next location was Squankum, now Williamstown, built in 1835, making bottles; then Estilville, Bridgeton, and Temperanceville (now part of Glassborough), built in 1836 and 1837; then Jersey City flint-glass works, built in 1840 or 1845. Somewhere about this date there was a flint-glass works built at Kaign's Point, now part of Camden. Then Greenbank, 1840 to 1845; New Columbia, 1845 to 1848; Jansboro', 1848; Balsto, about 1850; Crowleytown, 1850 to 1851; Clayton and New Brooklyn, about 1851 to 1852; Medford, Milford, and Lebanon, 1855; Bulltown, 1858; Quinton, 1858 to 1860; Salem, 1863; Westville, 1868; Riverside and Herman City, about 1870.

There was a glass works started at Elizabethport some twenty-five years ago and run for a short time; also, one started in Camden about 1868, and run for a short time.

This makes in all thirty-seven locations in New Jersey. Of these the following have gone out of existence entirely: Allowaystown, Columbia, Clementon, Tuckahoe, Hammonton, Jackson, Old Brooklyn, Estilville, Greenbank, New Columbia, Balsto, Crowleytown, Kaign's Point, Milltown, Bulltown, Lebanon, Westville, Jersey City, and Elizabethport—nineteen in all; two run two years, one three years, two five years, two ten years, four fifteen years, four twenty years, two thirty years, one thirty-five years, one forty-five years, while Waterford, Medford, Camden, New Brooklyn, Riverside, Herman City, and Port Elizabeth, seven in all, have not run for several years.

The balance of the locations, eleven in all, have forty-five furnaces, of which thirty-nine furnaces have run the past year, to wit: twelve window-glass, twenty-one green hollow ware, and six lime or white glass. Four of the green hollow ware and the six lime or white glass furnaces are situated at Millville, and are run by one firm, Messrs. Whitall, Tatum & Co.

<sup>a</sup> For most of the data contained in the very interesting account of glass-making in New Jersey I am indebted to Hon. John T. Bodine, of Williamstown, New Jersey, whose personal recollections extend back fifty-three years.

About four miles below Millville are located the largest beds of glass-house sand in the state, sand being dug for the Millville and the Philadelphia, New York, and Boston factories. The pits have been opened for more than fifty years. There are also large sand-beds near Williamstown that supply twelve factories a thousand tons each per year. There is sand in very many other localities in south Jersey, but there is none better than the Maurice river, Millville, or Williamstown sand.

Up to 1855 care was taken to locate glass works upon or near to large tracts of woodland. About the year 1856 the factories in New Jersey commenced to use anthracite coal, and since that time the pots have been enlarged at various times until they are more than three times the size they were when wood was used for melting. Mr. Bodine says:

The use of coal has made locations of glass factories at places other than upon water navigation in New Jersey very expensive, even with railroads. The cost of freight in getting coal and materials to and manufactured products from the marketable points of Philadelphia and New York is about 9 to 10 per cent. of the gross receipts of manufactured goods, while the only offset thereto is about 2 per cent. in the cost of sand and wood for annealing the ware. Many of the New Jersey works have been located where wood could be used. If the locations were abandoned, and the works removed to the large consuming points, the whole plant, so far as the building is concerned, would be lost. I find twenty-six of the factories among the forty-five contained in the eleven locations upon water navigation, and but for the advantage of water transportation we should not have as many glass factories as we now have.

#### GLASS-MAKING IN OHIO.

The information regarding glass-making in this state is exceedingly meager. It does not appear among the manufactures of the state at the census of 1810. In 1811 John Mellish, in his *Travels*, suggests that a well-organized manufactory of glass bottles would succeed, intimating that no such works existed. An account of Cincinnati, of date of June, 1815, states that a manufactory of green and window-glass and hollow ware was about to go into operation, to be followed the ensuing summer by another for white flint. Palmer's *Travels* in 1817 speaks of two glass houses in operation. The census of 1820 enumerates "glass, window, and hollow ware, chemical and philosophical apparatus", as among the manufactures of Hamilton county, the value of the product being \$19,000, and the statement is made that the works are languishing, owing to the supply overrunning the demand. Glass, both cut, flint, and window, was also reported as made at this census in Muskingum county. (a) At the tariff convention held in New York in 1831 a window-glass works is reported at Zanesville and another at Moscow, while at the census of 1840 none are reported. In 1850 Ohio is credited with six works; in 1860 with four, and in 1870 with nine, three of which are reported as plate, probably window-glass, and six as glassware. Of the history of these several establishments I have no details.

#### GLASS-MAKING IN MISSOURI. (b)

As early as 1842 efforts were made to establish the manufacture of glass at Saint Louis. In that year a company of gentlemen, with Mr. James B. Eads, who has since become known in connection with the magnificent Saint Louis bridge and the jetties at the mouth of the Mississippi river, established the works now known as the Saint Louis glass works. This works at first made flint-glass tumblers, etc., and it is stated that Mr. Eads, finding it impossible to get the proper workmen, himself made the pots used in this factory. Five years of toil and vexation was the only result, and he and his associates, finding success impossible, were forced to suspend payment and abandoned further effort. To the credit of Colonel Eads, it should be stated that in after years he paid up every dollar of indebtedness incurred. Thus the first glass-making venture west of the Mississippi river passed into history as a failure. The factory was changed to a green-bottle works by Mr. Eads' successors, and then in 1854 back to a flint works. In 1855-'56 a green-bottle house was added, and in 1861 Bayot & Cummings took the works, since which it has been a flint house, now manufacturing only flint bottles.

The second works, those of the Missouri Glass Company, began operations in 1851, making window-glass, but ceased after running two years, remaining idle until 1856, when they were purchased and changed to flint-glass; but after sinking considerable sums in fruitless efforts the parties owning them sold out and abandoned the field. These works, then, like the Saint Louis glass works, became the property of various persons, who at different times encountered unvarying failures, until at last, in 1865, operations were wholly abandoned and the building taken for the manufacture of agricultural machinery. The other Saint Louis glass works have all been established since 1870.

#### GLASS-MAKING IN OTHER STATES.

As to the history of glass in other states but little has been learned. Glass has been made in Vermont, but there is none made at present. Two glass-houses are reported in that state at the census of 1840, one in Addison and one in Chittenden county, but none are reported in 1850, 1860, or 1870, nor at the present census. In Rhode Island no glass, as far as I have been able to learn, was ever made, and the same is true of Maine and Delaware. In the southern states, with the exception of Virginia, Kentucky, and possibly Tennessee, I can find no record of glass-making.

a I have seen a statement that this Zanesville works was the first in Ohio, but I have been unable to verify it.

b For the facts in this sketch I am indebted chiefly to an article in the Saint Louis *Trade Review* and to Mr. J. K. Cummings, of Saint Louis.

It has already been stated that the glass-blowers that Albert Gallatin induced to aid him in starting the New Geneva works were on their way to establish a glass house near Louisville, Kentucky; but it seems to have been many years before any other glass-makers sought this state to practice their art. Cramer's *Navigators* for 1814 states that a glass house had lately been built at Louisville, but neither the census of 1820 nor that of 1830 gives any evidence of the existence of this factory. At that of 1840 one glass-cutting establishment is reported in Kentucky, but no glass works. In 1850 no glass works is reported, though the Covington flint-glass works was established in 1848. In 1860 statistics of one glassware establishment are given in Jefferson county, in which Louisville is situated, but no facts are given regarding Kenton county, in which Covington is located, though the Covington glass works inform me that their flint-house was established in 1848, and their green-glass house in 1860. In 1870 three works are reported.

The statement is frequently made that the first glass works west of Cincinnati was built at Alton, Illinois, and in the returns received from the Alton factory the date of establishment of this works is given as 1867. No glass is reported as made in this state in any of the censuses until that of 1870. A similar statement can be made of Indiana. Michigan has no place in the several censuses as a manufacturer of glass. No glass is reported as made in Wisconsin at any census, though an establishment was started shortly after the close of the census year 1880. Mississippi was building a works during the census year. Glass-making was established in California in 1863, or at least a works was in operation, but of the details of its history I have no record.

#### HISTORY OF THE MANUFACTURE OF PLATE-GLASS IN THE UNITED STATES. (a)

It is probable that the first attempt to manufacture in this country what is now known as plate-glass was made at Cheshire, Massachusetts, though some rough cast plate may have been made earlier at some of the window-glass works. The extensive deposits at this place of exceedingly good sand, which was at one time supposed to be the only sand in the country from which good glass could be made, no doubt had much to do with this early attempt to make plate-glass and determined the location of the works. In 1850 a window-glass factory was erected at Cheshire, which was run for two years on blown glass. In 1852-53 this was changed to a rough cast-plate factory. A large amount of money was expended in fitting up the works and putting in the necessary machinery and tools, but it was operated only for about six months, when the tables, tools, fixtures, etc., were removed to Brooklyn, New York, and a factory was there fitted up and operated through 1854 and 1855. Very little glass of a merchantable quality was made, and in 1856 the works were abandoned, (b) one of the chief causes of the failure, no doubt, being the small scale on which the works were projected and operated and the inexperience of the promoters. The manufacture of plate-glass requires large capital and experience, and it was not until these were brought together that the plate-glass industry was firmly established in this country and the product could compete with the foreign.

The second effort was made at Lenox Furnace, Massachusetts. In 1853 a glass works was erected at this place at a cost of \$30,000 for making window-glass by the Lenox iron works, a corporation owned by William A. Phelps, Oliver Peck, and James Collins, who ran the works for about two years on window-glass at a loss. In the fall of 1855 the window-glass business was abandoned. This property was leased with contract to sell to James N. Richmond, who organized a company called the National Plate Glass Company, and was converted into a plate-glass factory. The company spent a large amount of money in reorganizing the establishment and experimenting, having bought the tables and tools of the Brooklyn company. In 1856, after a heavy loss, the company failed, and in 1857 the property came back to the original owners, who started up the works and continued to run them with success till the spring of 1865. In 1862 the factory buildings, with a large amount of glass, were destroyed by fire. There was no insurance, and the loss was over \$25,000. In 1865 a company was organized, called the Lenox Plate Glass Company, consisting of the old parties with Messrs. Theodore and James Roosevelt, of New York city. Up to this time only rough plate was made, but it was the intention of this company to commence polishing as soon as suitable machinery could be obtained. It is worthy of notice that, although for a number of years plate-glass had been produced in England and in France, there had been scarcely any improvements in the machinery used. Some few years previous to this parties in the western part of the state of New York had invented and patented a machine for grinding and polishing marble slabs, and this was found to work admirably in polishing glass; but through the influence of Mr. John R. Platte, then agent for the British Plate Glass Company of England, the owners of the patent were induced to put up one of these machines for the company, on condition that if the working was satisfactory they were to buy the patent. The machine worked with satisfaction, doing its work in much less time than the old system. Mr. Servin states that the company paid about \$50,000 for the patent. The principle of this machine is now generally used, though with improvements, in

a The statements of fact contained in this history are derived chiefly from letters from Mr. A. T. Servin, of Lenox, Massachusetts, Mr. E. Ford, of Jeffersonville, Indiana, and Mr. E. A. Hitchcock, of Saint Louis, and from Mr. W. C. De Pauw's testimony before the tariff commission.

b This is Mr. Servin's statement. Mr. Ford, however, states that the first attempt was made at Williamsburg, New York, in 1850, on a small scale, for the manufacture of rough plate-glass only, but was abandoned. The next effort, he states, was by the same party at Green Point, New York, but this was also a failure. This, Mr. Ford states, was the parent of the Lenox works.



polishing plate. About this time the Lenox Plate Glass Company was organized. The inventor having patented another machine in 1866 and 1867, this company bought the patents and put up some costly machinery, which was not completed till 1868 and 1869. About this time, and for two or three years previous, a company in Philadelphia held patents for making cryolite, a mineral from Greenland, into a material called cryolite or hot-cast porcelain, resembling white marble when worked, but having all the qualities of glass. This material was worked in the same way as glass. Through statements of great profits in this manufacture the Lenox company were induced to allow a new company to be formed January 1, 1870, called the Lenox Glass Company, which took all the property of the old company and gave the Philadelphia company \$200,000 for their patents, also purchasing a large amount of cryolite from them. This new company expended a large amount in preparing for the cryolite manufacture, but after six or eight months working it was found to be a perfect failure, resulting in a total loss to the company of the cryolite and patents purchased, and in 1871 the company failed. The furnace has since been run on rough plate for a part of the time. In 1879 a large proportion of the glass property was sold at about one-thirtieth of its cost, and a new company has been formed, called the Lenox glass works.

The next works built in the United States were at New Albany, Indiana, and it was here that polished plate-glass was first successfully and continuously manufactured. In the year 1869 Mr. J. B. Ford conceived the idea of erecting works for manufacturing polished plate-glass, and with this in view he visited Lenox, gathered what information he could on the subject from the workmen there who had been employed abroad, and returned to New Albany with a determination to make polished plate. He immediately entered into negotiations with manufacturers of plate-glass machinery in Europe, and purchased one each of the best machines for grinding, smoothing, and polishing, and while waiting for their arrival, in company with his associates, built a works for rough plate. About the time the machinery arrived the works was burned, but a new one was built on a more extended scale. This new plant was measurably successful, but had to undergo the reverses that seems the fate of all plate-glass houses in this country. In 1872 Mr. Ford withdrew, since which time it has been run by Mr. W. C. De Pauw, who stated before the tariff commission that until 1879 the works made no money, though the quality of the glass for some time had equaled the imported.

In the same year that he withdrew Mr. Ford organized and built another works at Louisville. These he managed until 1875, when he left there and organized a works at Jeffersonville, Indiana, the city having offered him some ground valued at \$20,000. These works have been largely increased, make excellent plate, and were, with New Albany and Crystal City, Missouri, the works that made polished plate in the census year.

Shortly after the organization of the New Albany plate-glass works Mr. E. B. Ward, of Detroit, and others, induced by the very extensive deposit of sand of an excellent quality at Crystal City, Missouri, organized the American Plate Glass Company, with a capital stock of \$250,000, and began in 1872 the erection of works at the point named, this sum being increased in January, 1874, to \$500,000. In 1875 the manufacture of plate-glass was begun, though with appliances much inferior to those now in use, and a considerable quantity of glass of good quality was produced. The usual difficulties, however, which attend new industries, by reason of lack of the requisite experience, were encountered. The production was irregular and uncertain as to quality, and in 1876 the work was suspended for several months, with a view to its resumption under more favorable conditions. In October, 1876, the enterprise was reorganized by the formation of a new corporation (the present Crystal Plate Glass Company), composed of most of the stockholders in the old company, in which additional capital was invested, and which acquired the entire premises, plant, and a large stock of materials on hand. Mr. E. A. Hitchcock, of Saint Louis, president of the old company, continued in charge as president. During the winter of 1876-77 preparations were made for resuming work under such conditions as to profit by the experience already gained. Convinced by thorough examination of its superior advantages, a Siemens furnace was erected. These works have since been largely increased, and are producing plate-glass the equal of any made in the world.

An extensive works for the manufacture of plate-glass is also being built at Hite's station, on the West Pennsylvania railroad, near Pittsburgh, by Mr. Ford, who built the works near Louisville. (a)

Regarding the manufacture of plate-glass in this country, Mr. W. C. De Pauw, in his paper before the tariff commission, made some statements which he summarizes as follows:

- First. That all money put into plate-glass works in America prior to 1879 had been a total loss.
- Second. That some of the shrewdest, most energetic, and successful business men in Boston, New York, Philadelphia, Detroit, Chicago, Saint Louis, and Louisville had in the aggregate invested millions in plate-glass enterprises and lost the whole of it.
- Third. That no plate-glass had been made in America without loss to the maker prior to 1879.
- Fourth. That I, instead of having made a large fortune in a few years, as represented, have actually lost more than half a million dollars over and above all (very small) profit made since 1873.
- Fifth. That after a long, earnest struggle, I have succeeded in making good glazing glass at a small profit.
- Sixth. That Americans are paying about half as much for plate-glass to-day as they paid prior to the time plate-glass was made in the United States at my works.

#### IMPORTS OF GLASS INTO THE UNITED STATES.

In order to show the amount of glass received into this country, I append a table giving the imports of glass into this country in the years 1876 to 1880, showing quantities and values so far as they are given in the reports of the bureau of statistics, and also the value of each unit of quantity.



## MANUFACTURE OF GLASS.

TABLE SHOWING IMPORTS OF GLASS INTO THE.

Articles.	1876.			1877.		
	Quantities.	Value.	Value per unit of quantity.	Quantities.	Value.	Value per unit of quantity.
Total glass, and manufactures of.....		\$4,803,091 25			\$3,952,703 22	
Bottles:						
1 Empty.....		25,306 44			22,125 84	
2 Containing liquors..... number..	3,740,478.74			3,813,957.73		
3 Or jars filled with articles not otherwise provided for.....						
4 Crystals for watches.....		6,970 00			10,078 00	
5 Disks, or plates unwrought, for optical instruments.....		1,748 00			1,119 00	
Glassware:						
6 Porcelain, Bohemian, cut, engraved, painted, colored, printed, stained, silvered or gilded, not including plate-glass silvered, or looking-glass plates.....		567,269 17			406,705 62	
7 Plain, mold, and press, not cut, engraved, or painted.....		60,833 97			54,310 15	
Plate-glass, cast, polished, not silvered:						
8 Not above 10 by 15 inches..... square feet..	15,600.00	2,822 00	0.182	17,305.00	2,836 00	0.163
9 Above 10 by 15 inches, and not above 16 by 24..... do....	8,117.75	3,615 00	0.445	12,643.00	5,113 00	0.404
10 Above 16 by 24 inches, and not above 24 by 30..... do....	101,949.00	67,008 00	0.657	88,802.75	55,781 00	0.628
11 Above 24 by 30 inches, and not above 24 by 60..... do....	442,705.50	340,908 00	0.770	458,704.00	326,150 00	0.711
12 Above 24 by 60 inches..... do....	1,024,318.33	943,958 00	0.922	1,017,317.55	871,744 00	0.857
Plate-glass, cast, polished, silvered, or looking-glass plate:						
13 Not above 10 by 15 inches..... square feet..	250,895.50	52,791 00	0.210	219,531.00	40,437 00	0.184
14 Above 10 by 15 inches and not above 16 by 24..... do....	812,671.33	223,407 00	0.275	755,919.00	175,708 00	0.233
15 Above 16 by 24 inches and not above 24 by 30..... do....	898,597.00	319,964 00	0.352	821,430.00	268,274 00	0.327
16 Above 24 by 30 inches and not above 24 by 60..... do....	108,753.19	117,006 00	0.694	102,550.00	55,456 00	0.541
17 Above 24 by 60 inches..... do....	65,778.75	76,467 00	1.162	12,149.25	17,064 00	1.405
Plate-glass, rough, fluted, or rolled (excess of 1 pound per square foot in proportion):						
18 Not above 10 by 15 inches..... square feet..	2,203.00	120 00	0.053	4,077.00	395 00	0.097
19 Above 10 by 15 inches and not above 16 by 24..... do....	2,608.00	75 00	0.028	2,787.00	96 00	0.034
20 Above 16 by 24 inches and not above 24 by 30..... do....	23,838.00	1,800 00	0.076	20,832.00	1,616 00	0.078
21 Above 24 by 30 inches..... do....	870,783.50	33,741 00	0.039	258,708.00	13,201 00	0.051
Window-glass, cylinder, crown, or common, unpolished:						
22 Not above 10 by 15 inches..... pounds..	6,330,440.00	215,619 88	0.034	4,077,124.00	154,815 00	0.033
23 Above 10 by 15 inches, and not above 16 by 24..... do....	7,542,537.50	304,205 46	0.040	5,662,851.00	202,878 00	0.036
24 Above 16 by 24 inches, and not above 24 by 30..... do....	8,085,927.00	376,706 34	0.047	7,220,534.80	288,382 47	0.040
25 Above 24 by 30 inches..... do....	6,879,206.00	425,480 00	0.062	7,378,928.00	381,517 00	0.052
Window-glass, cylinder, and crown, polished:						
26 Not above 10 by 15 inches..... square feet..	539.00	117 00	0.217	5,438.00	1,144 00	0.210
27 Above 10 by 15 inches, and not above 16 by 24..... do....	1,244.00	477 00	0.383	6,208.00	1,704 00	0.274
28 Above 16 by 24 inches, and not above 24 by 30..... do....	72,084.75	8,391 00	0.116	15,062.00	5,288 00	0.338
29 Above 24 by 30 inches, and not above 24 by 60..... do....	2,316.00	1,221 00	0.527	2,404.00	1,078 00	0.448
30 Above 24 by 60 inches..... do....						
31 Manufactures of, not otherwise provided for.....		624,877 99			497,528 14	

# MANUFACTURE OF GLASS.

101

UNITED STATES IN THE YEARS 1876 TO 1880.

1878.			1879.			1880.		
Quantities.	Value.	Value per unit of quantity.	Quantities.	Value.	Value per unit of quantity.	Quantities.	Value.	Value per unit of quantity.
	\$3,331,857 25			\$3,281,420 09			\$5,133,272 42	
	23,710 40			20,676 00			43,700 56	
3,200,087.00			3,360,798.00			4,276,410.00		
	7,271 00			50,412 00			199,459 00	
	428 00			11,049 00			7,391 00	
				1,697 00			2,668 00	
	458,447 93			591,541 38			722,637 41	
	20,965 00			41,958 80			38,381 36	
10,252.00	1,858 00	0.181	14,388.00	2,711 00	0.189	108,732.00	16,200 00	0.149
12,601.16	4,413 00	0.350	27,817.00	8,724 00	0.319	46,185.80	14,721 00	0.319
58,340.50	33,106 00	0.567	90,434.91	32,888 00	0.364	157,804.92	50,326 00	0.319
392,594.16	280,587 00	0.729	562,071.08	240,480 00	0.428	719,873.06	285,419 00	0.397
756,770.29	658,560 00	0.870	889,035.12	421,401 00	0.485	874,521.64	390,741 00	0.447
121,213.00	18,607 75	0.154	128,904.75	23,992 00	0.186	230,728.42	50,823 00	0.220
619,379.50	133,430 00	0.215	697,652.50	105,437 00	0.237	1,000,349.42	269,421 00	0.269
912,375.50	277,113 00	0.304	1,081,357.00	342,750 00	0.317	1,048,187.61	557,998 00	0.339
85,545.00	41,885 00	0.489	162,961.00	45,460 00	0.442	153,637.00	75,218 00	0.490
1,284.50	1,251 00	0.974	1,034.66	1,245 81	1.204	6,020.06	4,274 73	0.710
80.00	5 00	0.063						
2,441.00	163 00	0.067	405.00	29 00	0.072	10,785.00	196 00	0.018
3,585.00	153 00	0.043	7,202.00	365 00	0.051	1,957.00	89 00	0.045
78,588.00	5,432 00	0.069	173,384.00	7,693 00	0.044	757,908.00	25,420 00	0.034
4,330,940.00	124,033 01	0.029	3,582,364.00	90,350 62	0.025	12,041,215.00	308,978 11	0.026
5,903,795.00	176,184 84	0.030	5,045,243.00	140,367 05	0.028	11,977,758.00	333,063 23	0.030
6,576,448.00	226,396 85	0.034	5,896,463.00	184,885 64	0.032	10,093,808.25	351,403 90	0.033
6,242,560.50	274,624 61	0.044	6,225,791.83	237,232 87	0.038	10,137,070.00	412,472 44	0.041
3,563.00	828 00	0.232	1,675.00	325 00	0.194	11,900.86	2,110 00	0.177
8,724.00	2,601 00	0.298	15,460.50	3,256 00	0.211	26,575.58	4,163 00	0.156
10,779.00	4,185 00	0.388	21,031.00	6,023 00	0.286	86,938.75	10,605 00	0.287
1,661.00	690 00	0.415	4,039.00	1,690 00	0.418	12,651.00	4,220 00	0.334
	539,096 96			660,863 92			951,047 68	

## INDEX TO GLASS.

## A.

A.	Page.		Page.
Advantages of Siemens' gas furnaces.....	36	Ancient glass.....	59-64
Aggry beads made in Phoenicia .....	60	Ancient glass a soda glass.....	30
Agricola's time, furnaces in .....	34	Ancient glass, coloring matter of.....	59
Air blast, cooling heated molds by .....	49	Ancient glass houses, sources of supply of soda for .....	30
Air bubbles in glass.....	44	Ancient pressed glass .....	58
Air, effect of, on pots.....	43	Ancients, extent of use of window-glass by the .....	56
Albany, account of glass-making at .....	93, 94	Ancient soda impure.....	31
Alexandria, Virginia, manufacture of glass at.....	78	Ancient window-glass, method of manufacture of .....	56
Alicant, Spanish soda of .....	31	Annealing flint-glass.....	51
Alkalies and other materials used in glass-making .....	30-34	Annealing ovens for plate-glass, description of .....	46
Alkalies, the chief, used in glass-making .....	30	Annealing ovens in glassware factories, number of .....	4
Alkaline rocks in Germany, Friederich Siemens quoted on use of.....	28	Annealing ovens in green-glass factories, number of .....	4
Alkaline rocks in Germany, Julius Falldt quoted on use of ..	28	Annealing ovens in plate-glass factories, number of .....	4
Alkaline rocks, use of, for bottle-glass .....	28	Annealing plate-glass.....	45
Allegheny county, manufacture of glass in, in the census year	88	Annual settlement of wages.....	8
Alumina in glass.....	34	Antiquity of window-glass, Winckelman's views on.....	56
Amelung, John Frederick, petition of, for aid in glass-making	95	Approximate composition of glass .....	19
Amelung, presentation of flint goblets by, to Washington ...	95	Arsenic used, amount of.....	18
American fire-clay used .....	18	Arsenic, use of, in glass-making .....	25-34
American glass, quality of (note) .....	69	Art glass.....	52
American invention, pressed glass an .....	58	Artificial glass, definition of (note) .....	20
American pot-clay, analyses of .....	40	Art uses of glass.....	22
American sand, Bontemps quoted on.....	26	Assyrian glass, character of .....	61
American sand, character of .....	28	Aurelian, ordinance of, regarding tribute on glass .....	59
American sand, deposits of .....	28	Austria, glass-spinning in .....	75
American sand, mode of occurrence of .....	25	Austria-Hungary, cooling in glass houses of .....	44
American sand, Mr. Henry Chance quoted on .....	26	Austria-Hungary, dimension of pots in glass houses of .....	44
American sand, Thomas Webb & Son quoted on.....	26	Austria-Hungary, duration of heating in glass houses of....	44
American stained glass (note).....	69	Austria-Hungary, duration of melting in glass houses of ....	44
Ammonia process for making soda .....	31	Austria-Hungary, manufacture of glass flowers in .....	75
Amount of production of Roman glass .....	62	Austria-Hungary, manufacture of glass wearing fabrics in...	75
Analyses of bottle-glass .....	23	Austria-Hungary, manufacture of plate-glass in .....	75
Analyses of English sand .....	26, 27	Austria-Hungary, number of plate-glass factories in .....	70
Analyses of flint-glass.....	23	Austria-Hungary, present condition of manufacture of glass in.....	74
Analyses of foreign glass sands .....	29	Austria-Hungary, proportion of batch in glass houses of....	44
Analyses of French pot-clay.....	40	Austria-Hungary's specialty in glass-making.....	70
Analyses of French sand .....	27	Austria-Hungary, statistics of glass manufacture in .....	75
Analyses of German pot-clay .....	40	Austria-Hungary, working in glass houses of .....	44
Analyses of glass sands of the United States .....	30	Austrian glass houses, sources of supply of sand for .....	28
Analyses of lead glass.....	23	Austrian glass pots, size of .....	41
Analyses of lime glass.....	23	Austrian sand, sources of supply of.....	28
Analyses of plate-glass.....	23	Austria, quartz still used in .....	28
Analyses of sand not always indicative of quality.....	25	Austro-Hungarian glass houses, use of Siemens' tank furnaces in .....	44
Analyses of Scotch pot-clay .....	40	Average daily earnings, fallacy of usual statements regarding	
Analyses of Stourbridge pot-clay .....	40		
Analyses of window-glass.....	23		
Analysis of American pot-clay .....	40		
Analysis of window-glass found at Pompeii .....	56		
Ancient Egyptian glass furnaces, remains of, found by Napo- leon I .....	60		
Ancient factories, location of, at mouths of rivers.....	25		
Ancient factories, sand used in .....	26		
		<b>B.</b>	
		Baccarat works, establishment of.....	66
		Bakewell, Mr. Thomas, and the manufacture of glass at Pitts- burgh .....	86
		Balls, method of manufacture of, by pressing .....	48
		Baltimore glass works, establishment of .....	95
		Barbarians, influence of, upon glass-making .....	65

**13**

	Page.		Page.
Baree of Bretagne .....	31	British imports of glass .....	72
Barilla, Spanish .....	31	British islands, modern manufacture of glass in.....	68
Barrels and casks used .....	18	Bubbles in glass .....	44
Basalt, decomposed, use of, for manufacturing (note).....	20	Building glass works, statistics of .....	3, 13, 14
Bastie glass, method of manufacture of .....	53	Bulk, difference in, of melted and unmelted charge .....	43
Batch, constituents of the .....	41	Burgin furnaces, number of .....	4
Batch, definition of .....	41	Byzantine glass .....	62
Batch, preliminary heating of .....	43	Byzantine glass, character of .....	62
Batch, proportion of, in glass houses of Austria-Hungary....	44	Byzantine glass, extent of its manufacture .....	62
Battery jars, method of manufacture of, by pressing .....	48		
Beads, manufacture of, in Virginia .....	78	<b>C.</b>	
Beer-bottles, number made .....	11	Calcar arch .....	43
Beets and grapes, potash made from .....	32	California, history of glass-making in .....	98
Belgian bottle-glass, constituents of .....	43	California, statistics of all works in, by counties .....	15
Belgian glass, exportation of .....	73	Capital invested in glass manufacture .....	3
Belgian glass, quality of .....	73	Carbonate glass, color of .....	31
Belgian glass, statistics of manufacture of .....	74	Carbon, use of, in glass .....	34
Belgian sand, sources of supply of .....	27	Carthaginian glass .....	61
Belgian window-glass .....	69	Carts in glass factories, number of .....	4, 5
Belgian window-glass, export of .....	69	Casks and barrels used .....	18
Belgian window-glass, importation of, into the United States..	69	Castellani on Venetian glass manufacture .....	76
Belgium, production of plate-glass in .....	70	Casting and pressing, related processes .....	45
Belgium's specialty in glass-making .....	69	Casting plate-glass .....	45
Bellaire, Ohio, glass-making at .....	79	Casting tables, description of .....	45
Beni-Hassan, figures on tombs at .....	57	Casting tables in plate-glass factories, number of .....	4
Beni-Hassan, glass-making figured on tombs at .....	59	Cast plate, composition of .....	19
Benrath's definition of glass (note) .....	19	Cathedral plate, establishments producing .....	3
Beazine, use of .....	4	Cause of the decline of the manufacture of glass in Rome....	62
Blast-furnace slag, a glass (n ) .....	20	Causes of failure of early attempts to establish glass manu-	
Blast-furnace slag, relative composition of, and glass .....	54	facture .....	81
Blast-furnaces, slag-glass from .....	54	Cave .....	35
Blast, use of, in cooling .....	44	Censuses, previous, comparison with .....	2
Blister in glass, cause of .....	45	Censuses, previous, omissions in .....	2
Blowing and pressing united to produce same form of glass..	45	Chance, Mr. Henry, quoted on American sand .....	26
Blowing flint ware, description of process .....	51	Chance's mixing machine .....	43
Blowing glass .....	50	Character of ancient window-glass .....	56
Blowing in molds, description of method .....	51	Character of Egyptian glass .....	60
Blown plate, definition of .....	20	Character of French sand .....	27
Blown plate, how made .....	51	Character of lead glass .....	21, 33
Blown window-glass, early manufacture of .....	57	Character of modern Spanish glass .....	67
Blown window-glass, Theophilus' account of .....	57	Character of Phœnician glass .....	61
Bodine, John T., on early glass-making in New Jersey .....	96	Character of Roman glass .....	62
Bohemian glass .....	67	Character of sulphate glass .....	31
Bohemian glass, character of .....	68	Chargers, mechanical .....	43
Bohemian glass, definition of .....	21	Charging .....	43
Bohemian glass houses, time of melting in .....	44	Cheapness of glass at Rome .....	62
Bohemian glass pots, size of .....	41	Chemical glass .....	19
Bohemian glass, quality of .....	70, 74	Chemical lime flint-glass, constituents of .....	42
Bohemian lime flint-glass, constituents of .....	42	Chemical classification of glass, difficulty of .....	19
Boilers in glassware factories, number of .....	4	Chemists' ware not included in report .....	1
Boilers in green-glass factories, number of .....	5	Chief alkalies used in glass-making .....	30
Boilers in plate-glass factories, number of .....	4	Chief constituents of glass .....	19
Boilers in window-glass factories, number of .....	4	Chief glass-making countries of Europe .....	69
Bontemps quoted on American sand .....	26	Children in glass factories .....	5
Boston, manufacture of crown-glass at .....	89	China, glass-making in .....	64
Bottle-glass (note) .....	20	Christianity, influence of, on the manufacture of glass .....	63
Bottle-glass, analyses of .....	23	Churches, use of window-glass in early .....	56
Bottle-glass, Belgian, constituents of .....	43	Church, influence of the, on glass-making .....	65
Bottle-glass, English, constituents of .....	43	Classification, chemical, of glass, difficulty of .....	19
Bottle-glass, flint and, manufactured in Europe .....	72	Classification, commercial, of glass, difficulty of .....	20
Bottle-glass, French, constituents of .....	43	Classification, composition and properties of glass .....	19-23
Bottle-glass, the term hollow-ware applied to .....	21	Classification of glass .....	1, 20
Bottle-glass, materials used for, proportion of .....	43	Classification of glass according to method of manufacture	
Bottle-glass, Pittsburgh, constituents of .....	43	(note) .....	20
Bottle-glass pots, size of .....	41	Classification of glass, Tomlinson's (note) .....	20
Bottle-glass, use of alkaline rocks for .....	28	Classification of glass, Ure's (note) .....	20
Bottles, manufacture of, in France .....	73	Classification of Gobeleterie .....	21
Bottles, manufacture of, in window-glass houses .....	84	Clay-grinding mills in glass factories, number of .....	4
Bottles, pressing .....	48	Clear white lime flint-glass, constituents of .....	42
Bridgeport, Ohio, glass-making at .....	79	Clinton, De Witt, on glass-making in New York .....	94
British exports of glass .....	72	Coal first used as a fuel in United States at Pittsburgh .....	83

	Page.		Page.
Coal, mineral, first use of .....	36	Cooling in glass houses of Austria-Hungary.....	44
Coal, substitution of, for wood in glass-melting.....	57	Cooling molds by air blast .....	49
Coal used, amount of .....	18	Cooling, time of .....	44
Coal, use of, in glass-making in 1810.....	87	Cooling, use of blast in .....	44
Coke used, amount of .....	18	Cooper's mixer .....	43
Colbert and glass-making in France .....	66	Cost of making glass, items of .....	x
Cold stoking .....	44	Cost of Siemens' tempered glass .....	54
Colored glass, classification of, chemically .....	20	Council of Ten, action of, on glass-making .....	65
Colored glass, definition of .....	20	Counties making glass, relative production of .....	11
Colored glass pots, size of .....	41	Covered pots, time of melting in .....	44
Coloring matter of ancient glass .....	59	Covered pots, use of, in glass-making .....	57
Color of carbonate glass .....	31	Craig & O'Hara asked to manufacture glass for public build- ings at Washington.....	84
Color of glass, effect of use of manganese on .....	25	Craig & O'Hara, glass manufacturers in Pittsburgh.....	83
Color of sand not always indicative of quality .....	25	Craig & O'Hara's glass works.....	82-84
Color of slag-glass .....	55	Cristaux same as lead flint.....	21
Color of sulphate glass .....	31	Crown-glass, definition of .....	20
Commercial classification of glass, difficulty of .....	20	Crown-glass making in New York in 1846.....	94
Common flint, definition of .....	21	Crown glass, manufacture of, at Boston .....	89
Comparison with previous censuses .....	2	Crown-glass, method of manufacture.....	20
Composition, approximate, of glass .....	19	Crown-glass, time of melting, in English houses.....	44
Composition, classification, and properties of glass.....	19, 23	Crown optical glass.....	21
Composition of cast plate.....	19	Crushing strength of glass.....	21, 22
Composition of enamel .....	21	Crystal glass, definition of .....	21
Composition of Egyptian glass .....	60	Cullet, proportion of .....	43
Composition of glass, difficult to obtain .....	41	Curvette, use of, in plate-glass works .....	45
Composition of green bottle-glass .....	19	Cutting flint-glass .....	51
Composition of green glass .....	21	Cylinder glass, definition of.....	20
Composition of lead flint .....	19		
Composition of lead glass .....	21		
Composition of lime flint .....	19	D.	
Composition of window-glass .....	19	Dampness, effect of, on soda window-glass .....	30
Composition, variability of .....	19	Decadence of Venetian glass-making .....	65
Condition of glass-making in 1608 .....	78	Decanters, early manufacture of, in Pittsburgh.....	86
Conductivity of glass .....	21	De Cesnola's discoveries of glass.....	61
Connecticut, first glass house in .....	94	Decline of the English glass industry.....	72
Connecticut, history of glass-making in .....	94, 95	Decolorizer, manganese not a permanent .....	33
Connecticut, monopoly of glass-making in, granted.....	95	Decolorizer, use of manganese as a .....	24
Connecticut, statistics of all works, by counties .....	15	Definition of glass, Benrath's (note).....	19
Connecticut, statistics of glass-making in, at various dates..	95	Definition of glass, Fownes' (note).....	19
Consolidated statistics of production, etc., of glassware .....	12	Definition of glass, Lardner's (note).....	19
Consolidated statistics of production, etc., of green glass....	12	Definition of glass, Ure's (note).....	19
Consolidated statistics of production, etc., of plate-glass....	12	Denny & Beelen's glass house at Pittsburgh.....	83, 84
Consolidated statistics of production, etc., of window-glass..	12	Destruction of first glass house in Virginia .....	78
Consolidated statistics of the materials used in the manufac- ture of glass.....	18	Devitrification in its relation to manipulation of glass .....	22
Constituents of Belgian bottle-glass .....	43	Difference in bulk of melted and unmelted charge .....	43
Constituents of Bohemian lime flint-glass.....	42	Difficulties attending the early manufacture of glass at Pitts- burgh.....	84-86
Constituents of chemical lime flint-glass.....	42	Difficulties attending the early manufacture of glass in Mary- land .....	95
Constituents of clear white lime flint-glass .....	42	Difficulties attending the manufacture of glass in Virginia...	78
Constituents of English bottle-glass .....	43	Difficulties attending the manufacture of plate-glass in the United States.....	98
Constituents of English lead flint-glass.....	42	Difficulty of comparison with previous censuses .....	2
Constituents of English plate-glass .....	42	Dimension of pots in glass houses of Austria-Hungary .....	44
Constituents of English window-glass.....	42	Direct-firing furnaces, number of.....	4
Constituents of French bottle-glass .....	43	Directory of glass works .....	ix
Constituents of French lead flint-glass .....	42	Discovery of glass.....	59
Constituents of French lime flint-glass .....	42	Discovery of soda-ash .....	31
Constituents of French plate-glass .....	42	District of Columbia, statistics of works in .....	15
Constituents of French window-glass .....	42	Division of labor at early glass works .....	34
Constituents of lead flint-glass .....	42	Double glass, definition of .....	20
Constituents of lime flint-glass .....	42	Double process, glass-making a .....	19
Constituents of lime-white flint-glass.....	42	Draft animals used in glass works, number and kind of.....	5
Constituents of Pittsburgh bottle-glass .....	43	Drays in glass factories, number of .....	4, 5
Constituents of Pittsburgh lead flint-glass .....	42	Drinking-glasses, Saxon .....	63
Constituents of Pittsburgh lime flint-glass .....	42	Druids' beads.....	64
Constituents of Pittsburgh window-glass.....	42	Drying of pots .....	41
Constituents of plate-glass .....	42	Duties on imports of glass, early action of Congress in levy- ing .....	95
Constituents of the batch .....	41	Ductility of glass .....	22
Constituents of window-glass .....	42	Dyottville glass works.....	81, 82
Constitutionality of loans of money to encourage manufac- tures discussed in Congress .....	95		
Construction of furnaces for different kinds of glass.....	35		

E.		F.	
	Page.		Page.
Earliest date assigned to the manufacture of Egyptian glass.	59	Europe, present condition of glass-making in	69-77
Early action of Congress levying duties on imports of glass.	95	Europe, production of plate-glass in	71
Early attempts at the use of salt-cake	31	Excellence of Phœnician glass	60
Early attempts to establish glass manufacture.	81	Exportation of Belgian glass	73, 74
Early attempts to make plate-glass in the United States	98	Export, first United States, of glass	77
Early French glass works	63	Export of Belgian window-glass	69
Early furnaces	34	Exports of glass, British	72
Early glass furnaces, description of	90		
Early glass-making in the British islands	64		
Early glass-making near Philadelphia	80		
Early glass, variety of	34		
Early glass works, division of labor at	34		
Early glass works in Gaul	63		
Early glass works in Spain	63		
Early manufacture of decanters in Pittsburgh	86		
Early manufacture of glass in Pittsburgh	84		
Early manufacture of mirrors in Germany	63		
Early manufacture of window-glass in Germany	63		
Early specimens of German glass	67		
Early times in France, use of window-glass in	56		
Early use of flint in glass-making	26		
Early use of quartz in glass-making	26		
Early Venetian glass-making	65		
Early window-glass works in England	56		
Earnings, average daily, elements necessary to ascertain	6		
Economy of Siemens' tank furnace	38		
Effect of air on pots	43		
Effect of lead in the manufacture of glass	33		
Effect of lime on glass	32		
Effect of pressing in cheapening glass	58		
Egypt, glass-making in, after the Christian era	59		
Egypt, glass-making materials in	60		
Egyptian furnaces, early	34		
Egyptian glass	59		
Egyptian glass, character and composition of	60		
Egyptian glass, earliest date assigned to the manufacture of	59		
Egyptian glass furnaces, ancient, remains of, found by Napoleon I.	60		
Egyptian glass-making, process of	60		
Egyptian glass, varieties of	60		
Egyptian soda, where procured	30		
Egypt, natron lakes of	30		
Egypt, state of the art in ancient	59		
Eichbaum, P. W., glass-worker	81-83		
Employés, number of	6		
Enamel, composition of	21		
England, early window-glass works in	56		
England, number of plate-glass factories in	70		
England's specialties in glass-making	69		
English art glass	69		
English bottle-glass, constituents of	43		
English fire-clay used, amount of	18		
English flint-glass	69		
English glass houses, sources of supply of sand for	27		
English glass houses, time of fining in	44		
English glass houses, time of melting in	44		
English glass industry, decline of	72		
English houses, time of melting flint-glass in	44		
English lead flint-glass, constituents of	42		
English plate-glass, constituents of	42		
English sand, analyses of	26, 27		
English sand, sources of supply of	26		
English window-glass, constituents of	42		
Engraving flint-glass	51		
Essex-street glass works	89		
Establishments in which glass was made in the census year	3		
Etching flint-glass	51		
Etching, invention of	67		
Etruscan glass	61		
Europe, chief glass-making countries of	69		
Europe, number of plate-glass factories in	70		
		Factories, plant of	4
		Fabdt, Julius, quoted on use of alkaline rocks in Germany	28
		Failure of early attempts to establish glass manufacture, causes of	81
		Falls of the Schuylkill, glass works at the	81
		Faults in glass	44, 45
		Fining	43, 44
		Fining, duration of, in glass houses of Austria-Hungary	44
		Fining, effect of too long continued	43
		Fining, heat of	43
		Fining, time of, in English houses	44
		Fining, time of, in lime glass houses	44
		Fining, time of, in the glass houses of the United States	44
		Fire-clay, American, used, amount of	18
		Fire-clay, English, used, amount of	18
		Fire-clay, German, used, amount of	18
		Fire polishing	40
		First export of glass from the United States	77
		First glass house in New York	93
		First glass house in Pittsburgh	83
		First glass house in the United States	77
		First glass made in the United States	77
		First glass works in Connecticut	94
		First glass works in Massachusetts	89
		First glass works in Missouri	97
		First glass works in New Hampshire	91
		First glass works in New Jersey	96
		First glass works in Pennsylvania	70
		First glass works in Philadelphia, Pennsylvania	80
		First glass works west of the Allegheny mountains	82
		First mention of glass in Rome	62
		First pressed glass	58
		First pressed tumbler	58
		First Roman glass works	62
		Flashed glass, definition of	20
		Flattening-ovens in window-glass factories, number of	4
		Flattening window-glass, description of process of	50
		Flint still used in Germany	27
		Flint- and bottle-glass manufacture in Europe	72
		Flint, common, definition of	21
		Flint, early use of, in glass-making	26
		Flint, German, definition of	21
		Flint-glass, analyses of	23
		Flint-glass, annealing	51
		Flint-glass, Bohemian lime, constituents of	42
		Flint-glass, chemical lime, constituents of	42
		Flint-glass, clear white lime, constituents of	42
		Flint-glass, cutting	51
		Flint-glass, definition of	20
		Flint-glass, English lead, constituents of	42
		Flint-glass, engraving	51
		Flint-glass, etching	51
		Flint-glass, first attempt at the manufacture of, west of the Allegheny mountains	85
		Flint-glass, French lead, constituents of	42
		Flint-glass, French lime, constituents of	42
		Flint-glass houses, time of melting in	44
		Flint-glass, lead, constituents of	42
		Flint-glass, lead, proportion of materials used in the manufacture of	42
		Flint-glass, lime, proportion of materials used in the manufacture of	42



	Page.		Page.
Flint-glass, lime, constituents of .....	42	Gas furnaces, number of .....	4
Flint-glass, lime-white, constituents of .....	42	Gas furnaces, time of melting in .....	44
Flint-glass making, early in Massachusetts, account of .....	89, 90	Gaul, early glass works in .....	63.
Flint-glass, manufacture of, in Philadelphia, Pennsylvania ..	82	German fire-clay used, amount of .....	18
Flint-glass, permanent establishment of the manufacture of, at Pittsburgh .....	86	German flint, definition of .....	21
Flint-glass, Pittsburgh lead, constituents of .....	42	German glass, early specimens of .....	67
Flint-glass, Pittsburgh lime, constituents of .....	42	German glass houses, location of .....	74
Flint-glass pots, size of .....	41	German glass pots, size of .....	41
Flint-glass, tools used in the manufacture of .....	51	German glass-workers in the United States, early .....	91
Flint, use of, in manufacture of glass .....	24	German pot-clay, analyses of .....	40
Flowers, glass, manufacture of, in Austria-Hungary .....	75	German sand, sources of supply of .....	27
Foreign glass sands, analyses of .....	29	German silvered plate, importation of, into the United States ..	70
Form of furnaces, object aimed at in the .....	35	Germany, early manufacture of mirrors in .....	63
Fowne's definition of glass (note) .....	19	Germany, early manufacture of window-glass in .....	63
France, Colbert and glass-making in .....	66	Germany, flint still used in .....	27
France, glass of .....	63	Germany, furnaces used in .....	74
France, manufacture of bottles in .....	73	Germany, influence of, on French glass-making .....	66
France, manufacture of lead flint-glass in .....	66	Germany, influence of Rome on glass manufacture in .....	63
France, manufacture of mirrors in .....	73	Germany, manufacture of mirrors in .....	74
France, manufacture of plate-glass in .....	73	Germany, number of plate-glass factories in .....	70
France, modern glass-making in .....	66	Germany, present condition of manufacture of glass in .....	74
France, number of plate-glass factories in .....	70	Germany, production of mirrors in .....	70
France, plate-glass making in .....	66, 73	Germany, quartz still used in .....	27
France, quartz still used in .....	27	Germany, statistics of manufacture of glass in .....	74
France's specialties in glass making .....	69	Germany's specialty in glass-making .....	70
France, use of window-glass in early times in .....	56	Gill furnace, description of .....	37
French bottle-glass, constituents of .....	43	Gill furnaces, number of .....	4
French glass houses, time of melting in .....	44	Glass, a fused mixture of two or more silicates .....	19
French glassware, taste displayed in the manufacture of .....	73	Glass and metallurgical slags .....	59
French glass works, early .....	63	Glass-bead manufacture in Venice .....	70
French lead flint-glass, constituents of .....	42	Glass-blowing, early, description of .....	57
French lime flint-glass, constituents of .....	42	Glass-blowing figured on tombs at Beni-Hassan .....	57
French plate-glass, character of .....	69	Glass, chemical .....	19
French plate-glass, constituents of .....	42	Glass, chief constituents of .....	19
French pot-clay, analyses of .....	40	Glass, classification of .....	1, 20
French sand, analyses of .....	27	Glass, definition of, Benrath's (note) .....	19
French sand, character of .....	27	Glass, definition of, Fownes' (note) .....	19
French sands, mode of occurrence of .....	25	Glass, definition of, Lardner's (note) .....	19
French stained glass .....	69	Glass, definition of, Ure's (note) .....	19
French white glass, character of .....	69	Glass, difficulty of chemical definition of .....	19
French window-glass, constituents of .....	42	Glass found at Poitiers .....	63
Frequency of payment .....	8	Glass-gall .....	30
Fritting .....	43	Glass-gall, or sandiver .....	43
Fritting furnaces .....	34	Glass, how used commercially .....	19
Fruit jars, number made .....	11	Glass in France .....	63
Fuel, coal first used as a, in United States at Pittsburgh .....	83	Glass, in the dark ages .....	66
Fuel, economy of, in Siemens' gas furnace .....	36	Glass, its composition, classification, and properties .....	19-23
Fuel used in early glass houses .....	36	Glass-makers, special privileges given to .....	63
Fuel used in Germany .....	74	Glass-making a double process .....	19
Fuel used in glass-making .....	4	Glass-making at Bellaire, Ohio .....	79
Furnaces .....	34-41	Glass-making at Jamestown, Virginia .....	77
Furnaces, building .....	1, 3, 13, 14	Glass-making at Keene, New Hampshire .....	92
Furnaces, construction of, for different kinds of glass .....	35	Glass-making at Martin's Ferry, Ohio .....	79
Furnaces, description of early glass .....	90	Glass-making at Newcastle-on-Tyne .....	64
Furnaces, early .....	34	Glass-making at Pembroke, New Hampshire .....	92
Furnaces idle during census year .....	1, 2, 3, 13, 14	Glass-making at Wheeling, West Virginia, history of .....	78
Furnaces, number of .....	3	Glass-making figured on tombs at Beni-Hassan .....	59
Furnaces, size of .....	36	Glass-making, history of some processes of .....	56, 58
Furnaces used in Germany .....	74	Glass-making in Bridgeport, Ohio .....	79
Fusion, effect of too long continued .....	43	Glass-making in California, history of .....	98
Fusion, heat of .....	43	Glass-making in China .....	64
Fusion, time of .....	43	Glass-making in Connecticut, history of .....	94, 95
<b>G.</b>		Glass-making in Egypt, after the Christian era .....	59
Gallatin's glass works .....	82	Glass-making in Germany .....	63
Gallatin's return on the manufacture of glass in the United States ..	87	Glass-making in Illinois, history of .....	98
Gas bubbles in glass .....	44	Glass-making in India .....	64
Gas furnaces .....	36	Glass-making in Ireland .....	64
Gas furnaces at Wheeling .....	79	Glass-making in Kentucky, history of .....	98
		Glass-making in Maryland, history of .....	95, 96
		Glass-making in Maryland in 1810 .....	96
		Glass-making in Maryland in 1820 .....	96



	Page.		Page.
Indiana, statistics of all works in, by counties .....	16	Lever-press for making pressed glass, description of .....	47
Influence of barbarians upon glass-making .....	65	Life of pots .....	41
Influence of Christianity on the manufacture of glass .....	63	Lime an important glass-making material .....	32
Influence of Germany on French glass-making .....	66	Lime, effect of, on glass .....	32
Influence of Rome on glass manufacture in Germany .....	63	Lime flint-glass, Bohemian, constituents of .....	42
Influence of the church on glass-making .....	65	Lime flint-glass, clear white, constituents of .....	42
Influence of the Renaissance on glass-making .....	65	Lime flint-glass, chemical, constituents of .....	42
Influence of the Roman conquest in extending glass manu- facture .....	63	Lime flint-glass, composition of .....	19
Influence of Venice on modern glass-making .....	64	Lime flint-glass, constituents of .....	42
Influence of Venice on the manufacture of English glass .....	68	Lime flint-glass, French, constituents of .....	42
Influence of weather on composition of glass .....	41	Lime flint-glass, Pittsburgh, constituents of .....	42
Influence of weather on melting glass .....	41	Lime flint-glass, proportion of materials used in the manu- facture of .....	42
Influences that determine the glass mixture .....	41	Lime glass, analyses of .....	23
Insolubility of glass .....	22	Lime glass as a rule a cheap glass .....	32
Insulators, method of manufacture of, by pressing .....	48	Lime glass, definition of .....	21
Intervals of payment .....	8	Lime-glass houses, time of firing in .....	44
Introduction of glass-making into Rome .....	62	Lime-glass houses, time of melting in .....	44
Iowa, statistics of all works in, by counties .....	16	Lime present in nearly all glasses .....	32
Ireland, glass-making in .....	64	Lime, sources of supply of .....	33
Iridescent glass, definition of .....	21	Limestone used, amount of .....	18
Iron in glass .....	33	Lime used, amount of .....	18
Iron in sand, effect of, on glass .....	24	Lime, use of, a modern discovery .....	32
Italian glass manufacture, statistics of .....	76	Lime-white flint-glass, constituents of .....	42
Italy, present condition of manufacture of glass in .....	76	Litharge or red lead used, amount of .....	18
<b>J.</b>		Litharge, use of .....	33
Jamestown, Virginia, glass-making at .....	77	Loans of money to encourage manufactures, constitutionality of, discussed in Congress .....	95
Jarves, Mr., on Venetian glass-making .....	65	Localities in which glass was produced .....	11
Johnson's <i>Rambler</i> quoted .....	22	Localities of the manufacture of glass in Great Britain .....	72
Joint molds .....	47	Location of ancient factories at mouths of rivers .....	25
<b>K.</b>		Location of German glass houses .....	74
Kalt-schüren .....	44	Location of plate-glass factories in Europe .....	70
Keene, New Hampshire, glass-making at .....	92	Location of window-glass factories in Europe .....	71
Kensington, Pennsylvania, glass works at .....	80	<i>London Pottery Gazette</i> on the invention of glass pressing .....	58
Kentucky, history of glass-making in .....	98	Looking-glass manufacture in Austria, thin sheet glass for ..	44
Kentucky, statistics of all works in, by counties .....	16	Loss in melting .....	44
<b>L.</b>		Loss of plate-glass in grinding, smoothing, and polishing .....	46
Lablane's discovery of soda-ash .....	31	Lottery for raising funds to establish glass-making in New Hampshire .....	92
Labor, division of, at early furnaces .....	34	Low countries, modern manufacture of glass in .....	68
Lamp chimneys, number made .....	11	Lowell, Massachusetts, early glass works in .....	90
Lamps, number made .....	11	Lumber used, amount of .....	18
Lamps, pressing .....	48	<b>M.</b>	
Lancaster, Pennsylvania, Baron Steigel's glass works at .....	80	Machinery for grinding plate-glass, description of .....	46
Lancaster, Pennsylvania, glass-making at .....	80	Machines used in glass works, kind and number of .....	5
Lardner's definition of glass (note) .....	19	Making soda, Solvay process for .....	31
Largest plates of glass made .....	46, 73	Making soda, the ammenia process for .....	31
Lead, effect of, in the manufacture of glass .....	33	Manganese, effect of use of, on color of glass .....	25
Lead, effect of proportion of, on time of melting .....	44	Manganese used, amount of .....	18
Lead flint-glass, composition of .....	19	Manganese, use of .....	33
Lead flint-glass, constituents of .....	42	Manganese, use of, as a decolorizer .....	24
Lead flint-glass, English, constituents of .....	42	Manipulation of glass, devitrification in its relation to .....	22
Lead flint-glass, French, constituents of .....	42	Manufacture of beads in Virginia .....	78
Lead flint-glass, manufacture of, in France .....	66	Manufacture of bottles in window-glass houses .....	84
Lead flint-glass, Pittsburgh, constituents of .....	42	Manufacture of bottles west of the Allegheny mountains ..	85
Lead flint-glass, proportion of materials used in the manu- facture of .....	42	Manufacture of glass in Allegheny county in the census year ..	88
Lead glass, analyses of .....	23	Manufacture of glass in Germany, statistics of .....	74
Lead glass, characteristics of .....	21	Manufacture of glass, use of salt in the .....	32
Lead glass, character of .....	33	Manufacture of salt-cake in the United States .....	32
Lead glass, composition of .....	21	Manufacture of soda-ash in the United States .....	32
Lead glass, early manufacture of .....	57	"Market-money," payment of .....	8
Lead glass, how distinguished from lime glass .....	21	Martin's Ferry, Ohio, glass-making at .....	70
Lead glass, invention of .....	57	Marver, use of .....	51
Lead glass, where made .....	33	Maryland, history of glass-making in .....	95, 96
Lead, use of, as a glass-making material a modern discovery ..	33	Maryland sand .....	29
Leer, description of .....	51	Maryland, statistics of all works in, by counties .....	16
Legislature, action of early Massachusetts, encouraging glass- making .....	89	Massachusetts, account of early flint-glass making in .....	90
Letter of transmittal .....	ix	Massachusetts, early plate-glass manufacture in .....	98
		Massachusetts, first glass works in .....	89

	Page.
Massachusetts, history of glass-making in .....	88-91
Massachusetts legislature, action of early, encouraging glass-making .....	89
Massachusetts, state bounty in, for glass-making .....	89
Massachusetts, statistics of all works in, by counties .....	16
Materials, alkalies and other, used in glass-making .....	30-34
Materials, mixing of .....	41-45
Materials, mixing the, influence of, on the character of the glass .....	43
Materials, proportion of, used in the manufacture of glass ....	42, 43
Materials, proportion of, variable .....	41-45
Materials used in manufacture of glass, consolidated statistics of .....	18
Materials used in manufacture of glassware, value of .....	9
Mechanical chargers .....	43
Mechanical mixers, use of .....	43
Melting .....	43
Melting, duration of, in glass houses of Austria-Hungary ....	44
Melting, effect of proportion of lead on time of .....	44
Melting, effect of proportion of sand on time of .....	44
Melting, effect of too long continued .....	43
Melting glass .....	41-45
Melting, loss in .....	44
Melting-pots, size of, for manufacture of plate-glass .....	45
Melting, time of, depends on furnace, materials, and size of pots .....	43
Melting, time of, in Bohemian glass houses .....	44
Melting, time of, in covered pots .....	44
Melting, time of, in English glass houses .....	44
Melting, time of, in French glass houses .....	44
Melting, time of, in gas furnaces .....	44
Melting, time of, in the glass houses of the United States ....	44
Metallurgical slags, glass and .....	59
Metallurgy, influence of, on early glass-making .....	59
Method of manufacture, classification of glass according to (note) .....	20
Method of manufacture of ancient window-glass .....	56
Method of washing sand to remove impurities (note) .....	24
Methods of glass-working .....	45-55
Methods of payment .....	8
Michigan, statistics of all works in, by counties .....	16
Milton vase .....	52
Mineral coal, first use of .....	36
Mirrors, early manufacture of, in Germany .....	63
Mirrors, manufacture of, in France .....	73
Mirrors, manufacture of, in Germany .....	74
Mirrors, production of, in Germany .....	70
Mirrors, tin amalgam for, a German invention .....	63
Mississippi, statistics of all works in, by counties .....	16
Missouri, history of glass-making in .....	97
Missouri, manufacture of plate-glass in .....	99
Missouri sand .....	29
Missouri, statistics of all works in, by counties .....	16
Mixer, Cooper's .....	43
Mixers, mechanical, use of .....	43
Mixing-machine, Chance's .....	43
Mixing materials .....	41-45
Mixing sand used, amount of .....	18
Mixing the materials, influence of, on the character of the glass .....	43
Mixture of two or more silicates, glass, a fused .....	19
Mode of occurrence of French sand .....	25
Modern furnaces, description of .....	35
Modern glass .....	64-65
Modern glass-making dates from Venice .....	64
Molded glass, Roman .....	57
Molding articles with lateral designs .....	47
Molding curved hollow articles .....	46
Mold marks on pressed ware .....	47
Molds, blowing in, description of method of .....	51
Molds, cooling, by air blast .....	49

	Page.
Molds, early use of.....	57
Molds for making pressed glass, description of.....	47
Monkey-ovens in window-glass factories, number of.....	4
Monopoly of glass-making in Connecticut granted.....	94
Moore, Governor, on glass-making in New York.....	93
Mouths of rivers, location of ancient factories at.....	25
Mules in glass factories, number of.....	4, 5
Murano, establishment of glass manufacture at.....	65
<b>N.</b>	
Nails used.....	18
Natron lakes of Egypt.....	30
Natural glass, definition of (note).....	20
Newcastle-on-Tyne, glass-making at.....	54
New England sand.....	29
New Hampshire, description of early method of glass-making in.....	90, 91
New Hampshire, history of glass-making in.....	91-93
New Hampshire, statistics of all works in, by counties.....	16
New Jersey, glass sand in.....	97
New Jersey, history of glass-making in.....	96, 97
New Jersey, John T. Bodine on early glass-making in.....	96
New Jersey sand.....	29
New Jersey, statistics of all works in, by counties.....	17
New Jersey, statistics of glass-making in, at various dates.....	96
New York, crown-glass making in, in 1846.....	94
New York, De Witt Clinton on glass-making in.....	94
New York, glass-making in, early in the 19th century.....	94
New York, Governor Moore on glass-making in.....	93
New York, history of glass-making in.....	93, 94
New York, statistics of all works in, by counties.....	17
Nicholson furnace, description of.....	37
Nicholson furnaces, number of.....	4
Nitrate of soda used, amount of.....	18
Nitrate of soda, use of.....	32
Normandy, glass-making in.....	63
Norton, Captain, sent to Virginia to make glass.....	78
Norway, glass-making in.....	70
Norway, present condition of manufacture of glass in.....	77
<b>O.</b>	
Object aimed at in the form of furnaces.....	35
Obsidian (note).....	20
Ohio, history of glass-making in.....	97
Ohio, statistics of all works in, by counties.....	17
Omissions in previous censuses.....	2
Optical glass.....	21
Optical glass, character of.....	46
Optical glass, Guinand's method of making.....	46
Ordinance of Aurelian regarding tribute on glass.....	59
Ovens used in glass works, kind and number of.....	6
<b>P.</b>	
Painted glass a German invention.....	63
Painted glass, classification of, chemically.....	20
Painted glass, definition of.....	20
Painted glass, statistics of, not included in report.....	1
Palmer, Mr. Charles, on the production of plate-glass in England, France, and Belgium.....	70, 71
Patent plate, definition of.....	20
Patent plate, how made.....	51
Payment, frequency of.....	8
Payment in kind.....	8
Payment, methods of.....	8
Payment, peculiarities of.....	8
Pearl-ash used, amount of.....	18
Pelé's hair (note).....	20
Pellatt on the invention of glass pressing.....	58
Pembroke, New Hampshire, glass-making at.....	92
Pennsylvania, glass works in, in 1810.....	82
Pennsylvania, history of glass-making in.....	79-88
Pennsylvania, statistics of all works in, by counties.....	17

	Page.		Page.
Permanent establishment of the manufacture of flint-glass at		Plate-glass, Thevart's invention of	56
Pittsburgh	86	Plate-glass, thickness of	46
Persia, glass-making in	64	Plate-glass, time of melting, in English houses	44
Petition of John Frederick Amelung for aid in glass-making	95	Plate-glass works, furnaces in, number of	3
Petroleum, use of	4	Plate-glass works, pots in, number of	3
Philadelphia, early glass-making near	80	Pliny's story of the discovery of glass	59
Philadelphia, manufacture of flint-glass in	80	Poitiers, glass found at	63
Phœnicia, Aggry beads made in	60	Poitiers, variety of glass found in tombs at	63
Phœnician glass	25, 60	Polished plate, definition of	20
Phœnician glass, character of	61	Polished plate, establishments producing	3
Phœnician sand	25	Polished plate-glass, value per square foot of	10
Pittsburgh bottle-glass, constituents of	43	Polishing-machines in plate-glass factories, number of	4
Pittsburgh, history of glass manufactures in	85-87	Polishing plate-glass	46
Pittsburgh glass houses, sources of supply of sand for	29	Pompeii, window-glass discovered at	56
Pittsburgh lead flint-glass, constituents of	42	Pontil, use of	51
Pittsburgh lime flint-glass, constituents of	42	Portland vase, the	52
Pittsburgh, statistics of the manufacture of glass in, for a series of years	87, 88	Portugal, glass-making in	70
Pittsburgh window-glass, constituents of	42	Portugal, present condition of glass-making in	77
Plant of factories	4	Potash, early history of use of	32
Plate-glass, analyses of	23	Potash, early sources of supply of	32
Plate-glass, annealing	45	Potash, use of, recent	32
Plate-glass, annealing-ovens for, description of	46	Pot-clay, American, analyses of	40
Plate-glass, casting	45	Pot-clay, analyses of	40
Plate-glass, capital invested in	3	Pot-clay, different localities in which produced	39
Plate-glass, chemically, classification of	20	Pot-clay, preparation of, for making pots	40
Plate-glass, consolidated statistics of production, etc.	11	Pot-metal	26
Plate-glass, constituents of	42	Pots	34, 41
Plate-glass, description of machinery for grinding	46	Pots, covered, use of, in glass-making	57
Plate-glass, difficulties in the way of the manufacture of, in the United States	98	Pots, difficulty of setting	40, 41
Plate-glass, early attempts to make, in the United States	98	Pots, drying of	40
Plate-glass, English, constituents of	42	Potsherds, use of	40
Plate-glass factories, definition of	1	Pots, how made	40
Plate-glass factories in Europe	70	Pots, life of	41
Plate-glass, French, character of	69	Pots, number of	3
Plate-glass, French, constituents of	42	Pots, shape of	41
Plate-glass, grinding, description of process of	46	Pots, size of	41-44
Plate-glass, history of manufacture of, in France	56	Pots, size of, effect of, on time of melting	44
Plate-glass in the United States, history of the manufacture of	98	Pots, soundness of, how tested	41
Plate-glass, kind of, produced at the different establishments	3	Pots used, number of	18
Plate-glass, largest plates made	46, 73	Power used in glass works	5
Plate-glass, loss of, in grinding, smoothing, and polishing	46	Preliminary heating of batch	43
Plate-glass making in France	66	Preliminary report, March 30, 1880	ix
Plate-glass manufacture, early, in Massachusetts	98	Prepared quartz, sand and, relative cost of, in Vienna	28
Plate-glass manufacture in Belgium, establishment of	57	Presentation of flint goblets to Washington by Mr. Amelung	95
Plate-glass manufacture in England, establishment of	57	Present condition of glass-making in Austria-Hungary	74, 75
Plate-glass, manufacture of, in Austria-Hungary	75	Present condition of glass-making in Europe	69-77
Plate-glass, manufacture of, in France	73	Present condition of glass-making in Germany	74
Plate-glass, manufacture of, in Indiana	99	Present condition of glass-making in Holland	77
Plate-glass, manufacture of, in Missouri	99	Present condition of glass-making in Italy	76
Plate-glass, Mr. Charles Palmer on the production of, in England, France, and Belgium	70, 71	Present condition of glass-making in Norway	77
Plate-glass, polishing	46	Present condition of glass-making in Portugal	77
Plate-glass pots, size of	41	Present condition of glass-making in Russia	76
Plate-glass, prices of, in Europe	71	Present condition of glass-making in Spain	77
Plate-glass, process of manufacture of	45	Present condition of glass-making in Sweden	76
Plate-glass, statistics of production of	10	Pressed glass an American invention	58
Plate-glass, production of, in Belgium	70	Pressed glass, ancient, how made	58
Plate-glass, production of, in England	70	Pressed glass, description of process of manufacture	47
Plate-glass, production of, in Europe	70, 71	Pressed glass, history of the invention of	58
Plate-glass, production of, in France	70	Pressed glass, lever-press for making, description of	47
Plate-glass, production of, value of	10	Pressed glass, molds for making, description of	47
Plate-glass, product of, value of	9	Pressed glass, the first	58
Plate-glass, proportion of materials used in manufacture of	42	Pressed tumbler, the first	58
Plate-glass, relative productive rank of the states in	9	Presses in glassware factories, number of	4
Plate-glass, results of the attempt to manufacture, in the United States	99	Pressing, blowing and, united to produce same form of glass	45
Plate-glass, rolling	45	Pressing bottles	48
Plate-glass, size of, made at Saint-Gobain	73	Pressing, casting and, relative processes	45
Plate-glass, size of melting-pots for manufacture of	41, 45	Pressing curved hollow articles	48
Plate-glass, smoothing	46	Pressing, effect of, in cheapening glass	58
		Pressing goblets	48
		Pressing lamps	48
		Pressing, method of manufacture of balls by	48
		Pressing, method of manufacture of battery jars by	48

	Page.		Page.
Pressing, method of manufacture of insulators by .....	48	Salt, use of, in the manufacture of glass .....	32
Pressing process, improvements in .....	47	Salviati and Venetian glass-making .....	65
Pressing taper articles .....	48	Sand .....	24-30
Prices of plate-glass in Europe .....	71	Sand, American, Bontemps quoted on .....	26
Prince Rupert's drops .....	21, 53	Sand, American, character of .....	28
Privileges, special, given to glass-makers .....	63	Sand, American, mode of occurrence of .....	25
Prize offered for glass-making .....	81	Sand, American, Mr. Henry Chance quoted on .....	26
Process for making soda, the ammonia .....	31	Sand, American, Thomas Webb & Son quoted on .....	26
Process for making soda, the Solvay .....	31	Sand, analysis of, not always indicative of quality .....	25
Process of manufacture of plate-glass .....	45	Sand and prepared quartz, relative cost of, in Vienna .....	28
Productive rank of the states, relative .....	9	Sand, Austrian, sources of supply of .....	28
Product of glass, value of .....	9	Sand, Belgian, sources of supply of .....	27
Profit in glass-making, no attempt to show .....	ix	Sand, color of, not always indicative of quality .....	25
Properties, composition, and classification of glass .....	19-23	Sand, deposits of American .....	28
Properties of glass .....	21, 22	Sand, effect of proportion of, on time of melting .....	44
Proportion of batch in glass houses of Austria-Hungary .....	44	Sand, English, analyses of .....	26, 27
Proportion of materials used in the manufacture of glass .....	41-43	Sand, English, sources of supply of .....	26
Proportion of silica in glass .....	24	Sand for English glass houses, sources of supply of .....	27
<b>Q.</b>		Sand for Pittsburgh glass houses, sources of supply of .....	29
Quality of American glass (note) .....	69	Sand for Swedish glass houses, sources of supply of .....	28
Quality of Belgian glass .....	74	Sand for Wheeling glass houses, sources of supply of .....	29
Quality of Bohemian glass .....	70, 74	Sand, French, analyses of .....	27
Quality of German glass .....	74	Sand, French, character of .....	27
Quartz, early use of, in glass-making .....	26	Sand, French, mode of occurrence of .....	25
Quartz still used .....	27, 28	Sand, German, sources of supply of .....	27
Quartz, use of, in manufacture of glass .....	24	Sand, grinding, used, amount of .....	18
<b>R.</b>		Sand, Herzogenrath (German) .....	28
<i>Rambler</i> , Johnson's, quoted .....	22	Sand, Hohenbocka (German) .....	28
Range of wages .....	6, 7	Sand, Illinois .....	29
Raw glass, production of, in Austria .....	44	Sand, impurities in, and their removal .....	24
Reaumur's porcelain .....	22	Sandiver, or glass-gall .....	30, 43
Red lead or litharge used, amount of .....	18	Sand, Maryland .....	29
Red lead, use of .....	33	Sand, Missouri .....	29
Refining glass in Austria .....	44	Sand, mixing, used, amount of .....	18
Refining, heat of .....	43	Sand, mode of occurrence of .....	25
Refining, time of .....	43	Sand, New England .....	29
Remains of ancient Egyptian glass furnaces found by Napoleon I. ....	60	Sand, New Jersey .....	29
Renaissance, influence of the, on glass-making .....	65	Sand of the river Belus .....	59
Report, preliminary, March 30, 1880 .....	ix	Sand of United States, superiority of the .....	26
Report, this, scope of .....	1	Sand, Phœnician .....	25
Revenue scheme, Townsend's, effect of, on glass-making .....	80	Sand, river or sea .....	25
Revival of Venetian glass-making .....	65	Sand, glass, analyses of foreign .....	29
Reworked glass not included in report .....	1	Sand, glass, analyses of United States .....	30
Richmond, Virginia, manufacture of glass at .....	78	Sand, sources of supply of, for Austrian glass houses .....	28
River or sea sand .....	25	Sand, Swedish, sources of supply of .....	28
Rochette of Syria .....	31	Sand, tests of .....	25
Rolled cathedral plate, definition of .....	20	Sand used in ancient factories .....	26
Rolled plate .....	46	Saxon drinking glasses .....	63
Rolled plate, definition of .....	20	Scope of report .....	1
Rolling plate-glass .....	45	Scotch pot-clay, analyses of .....	40
Roman conquest, influence of the, in extending glass manufacture .....	63	Scotland, glass-making in .....	64
Roman glass, amount of production of .....	62	Scott's glass house at Pittsburgh .....	83
Roman glass, specimens of, found in many countries .....	62	Sea or river sand .....	25
Roman molded glass .....	57	Sea-plants, soda from ashes of .....	31
Romans, use of window-glass by the .....	56	Second attempt at glass-making in the United States .....	78
Rough plate .....	46	Seed in glass, cause of .....	45
Rough plate, definition of .....	20	Setting of pots .....	41
Rough plate, establishments producing .....	3	Seybert's <i>Statistical Annals of the United States</i> quoted (note) ..	2
Russia, history of glass-making in .....	68, 69	Shape of pots .....	41
Russian glass manufacture, statistics of .....	76	Sheet glass, definition of .....	20
Russia, number of plate-glass factories in .....	70	Sheet glass, thin, for looking-glass manufacture in Austria ..	44
<b>S.</b>		Siège shops worked in glassware factories, number of .....	4, 35
Saint-Gobain Company .....	73	Siemens, Friedrich, quoted on use of alkaline rocks in Germany .....	28
Salt-cake, early attempts at the use of .....	31	Siemens' furnaces, number of .....	4
Salt-cake first used in the United States .....	31	Siemens' furnace, use of, in the United States .....	37
Salt-cake, manufacture of, in the United States .....	32	Siemens' gas furnaces .....	36
Salt-cake used, amount of .....	18	Siemens' tank furnace .....	37, 38
Salt used, amount of .....	18	Siemens' tank furnace for window-glass, illustration of .....	39
		Siemens' tank furnaces, use of, in Austro-Hungarian glass houses .....	44
		Siemens' tempered glass .....	54



Siemens' tempered glass, process of manufacture of.....	54	Stained glass, French .....	Page. 09
Silica in glass, proportion of .....	24	Stained glass, statistics of, not included in report .....	1
Siliceous rocks, use of in manufacture of glass.....	24	State bounty in Massachusetts for glass-making .....	89
Size of Austrian glass pots .....	41	State of the art in ancient Egypt.....	59
Size of Bohemian glass pots.....	41, 44	States, relative productive rank of the .....	9
Size of bottle-glass pots.....	41	Statistics for 1870.....	2
Size of colored-glass pots .....	41	Statistics for 1880, summary of .....	1
Size of English pots .....	41, 44	Statistics of all the glass works of the United States, consoli- dated, by states.....	15
Size of flint-glass pots .....	41	Statistics of all the glass works of the United States, by states and counties.....	15, 16, 17
Size of French pots.....	41, 44	Statistics of glass factories in Spain .....	77
Size of furnaces .....	36	Statistics of glass-making in Austria-Hungary .....	75
Size of German glass pots.....	41	Statistics of glass-making in Belgium .....	74
Size of melting-pots for manufacture of plate-glass .....	45	Statistics of glass-making in Connecticut at various dates....	95
Size of plate-glass made at Saint-Gobain works.....	73	Statistics of glass-making in Great Britain.....	72
Size of plate-glass pots .....	41	Statistics of glass-making in Holland.....	77
Size of pots, effect of, on time of melting.....	44	Statistics of glass-making in Italy .....	76
Size of pots in different countries .....	41	Statistics of glass-making in New Jersey at various dates....	96
Slag, blast-furnace, a glass (note) .....	20	Statistics of glass-making in Norway .....	77
Slag glass, color of.....	55	Statistics of glass-making in Pittsburgh for a series of years. 87, 88	
Slag glass from blast furnaces.....	54	Statistics of glass-making in Russia .....	76
Slag glass, manufacture of .....	55	Statistics of glass-making in Sweden .....	76
Smoothing-machines in plate-glass factories, number of.....	4	Statistics of glass-making in Venice .....	76
Smoothing plate-glass .....	46	Statistics of idle and building glass works .....	2, 3, 13, 14
Soda, ancient, impure .....	31	Steam-engines in glass factories, number of.....	4, 5
Soda-ash, Lablanc's discovery of .....	31	Steigels, Baron, glass works, at Lancaster .....	80
Soda-ash, manufacture of, in the United States.....	32	Stirring of the materials, how accomplished .....	43
Soda-ash used, amount of .....	18	Store-pay.....	8, 9
Soda, Egyptian, where procured.....	30	Stourbridge pot-clay, analyses of .....	40
Soda from ashes of sea-plants .....	31	Strass .....	21
Soda glass, ancient glass a .....	30	Strass, use of, in imitations of precious stones .....	46
Soda, imports of .....	31	Straw and hay used, amount of .....	18
Soda, nitrate of, use of .....	32	Strength, crushing, of glass .....	21, 22
Soda, production of .....	31	Strength, tensile, of glass .....	21, 22
Soda, sources of supply of, for ancient glass houses .....	30	Striae in glass, cause of.....	45
Soda, Spanish, of Alicante.....	31	Strings in glass, cause of.....	45
Soda window-glass, effect of dampness on .....	30	Sulphate glass.....	31
Soluble glass, definition of.....	21	Summary of statistics for 1880.....	1
Soluble glass, uses of.....	21	Superiority of the sand of the United States .....	26
Solvay process for making soda .....	31	Sweden, glass-making in .....	70
Soundness of pots, how tested .....	41	Sweden, present condition of manufacture of glass in.....	76
Sources of supply of Austrian sand .....	28	Sweden, statistics of glass manufacture in .....	76
Sources of supply of Belgian sand .....	27	Swedish glass houses, sources of supply of sand for .....	28
Sources of supply of English sand.....	26	Swedish sand, sources of supply of .....	28
Sources of supply of German sand.....	27	Syria, rochette of .....	31
Sources of supply of lime .....	33		
Sources of supply of potash, early .....	32		
Sources of supply of sand for Austrian glass houses.....	28		
Sources of supply of sand for English glass houses .....	27		
Sources of supply of sand for Pittsburgh glass houses .....	29		
Sources of supply of sand for Swedish glass houses .....	28		
Sources of supply of sand for Wheeling glass houses.....	29		
Sources of supply of soda.....	31		
Sources of supply of soda for ancient glass houses.....	30		
Sources of supply of Swedish sand.....	28		
Spain, early glass works in.....	63		
Spain, glass-making in .....	70		
Spain, modern glass manufacture in.....	66, 67		
Spain, present condition of glass-making in.....	77		
Spain, statistics of glass factories in.....	77		
Spanish barilla .....	31		
Spanish glass, character of modern.....	67		
Spanish soda of Alicante .....	31		
Special privileges given to glass-makers .....	63		
Specialties, England's, in glass-making.....	69		
Specialties, France's, in glass-making.....	69		
Specialty, Austria-Hungary's, in glass-making.....	70		
Specialty, Belgium's, in glass-making.....	69		
Specialty, Germany's, in glass-making.....	70		
Specific gravity of glass.....	21		
Specimens of Roman glass found in many countries.....	62		
Spun glass, definition of .....	21		
Stained glass, definition of .....	20		

	Page.		Page.
Time of cooling.....	44	Water glass, uses of.....	21
Time of fining in English houses.....	44	Watson, Elkanah, on glass-making in Albany.....	93
Time of fining in lime-glass houses.....	44	Waves in glass.....	45
Time of fining in the glass houses of the United States.....	44	Wearing fabrics, glass, manufacture of, in Austria-Hungary.....	75
Time of melting crown-glass in English houses.....	44	Weather, influence of, on composition of glass.....	41
Time of melting depends on furnace, materials, and size of pots.....	43	Weather, influence of, on melting glass.....	41
Time of melting, effect of proportion of lead on.....	44	Webb, Thomas, & Son, quoted on American sand.....	26
Time of melting, effect of proportion of sand on.....	44	Wellsburg, West Virginia, manufacture of glass at.....	78
Time of melting, effect of size of pots on.....	44	West Virginia, history of glass-making in.....	78, 79
Tin amalgam for mirrors a German invention.....	63	Wheeling, gas furnaces at.....	79
Tomlinson's classification of glass (note).....	20	Wheeling glass houses, sources of supply of sand for.....	29
Tools used in the manufacture of flint-glass.....	51	Wheeling, West Virginia, history of glass-making at.....	78, 79
Toughened glass.....	52	White glass, French, character of.....	69
Toughened glass, definition of.....	21	Winckelman's views on the antiquity of window-glass.....	56
Townsend's revenue scheme, effect of, on glass-making.....	80	Window-glass, analyses of.....	23
Transmittal, letter of.....	ix	Window-glass, ancient, character of.....	56
Transparent glass, earliest specimen of.....	61	Window-glass, average value per box of.....	10
Tribute on glass, ordinance of Aurelian regarding.....	59	Window-glass, Belgian.....	69
Truck payment.....	8	Window-glass, Belgian, importation of, into the United States.....	69
Tumblers, number made.....	11	Window-glass blowing.....	50
Tumbler, the first, pressed.....	58	Window-glass, blown, early manufacture of.....	57
<b>U.</b>		Window-glass, blown, Theophilus' account of.....	57
United States, first glass house in the.....	77	Window-glass, capital invested in.....	3
United States, glass sands of the, analyses of the.....	30	Window-glass, classification of, chemical.....	20
United States, history of glass-making in.....	77-79	Window-glass, composition of.....	19
United States, history of the manufacture of plate-glass in the.....	98, 99	Window-glass, consolidated statistics of, production, etc.....	12
United States, imports of glass into the.....	99-101	Window-glass, constituents of.....	42
United States, results of attempts to manufacture plate-glass in the.....	99	Window-glass cylinders, how opened.....	50
United States, salt-cake first used in the.....	31	Window-glass, decoration of, in France.....	73
United States, second attempt at glass-making in the.....	78	Window-glass, defects of.....	50
United States, superiority of sand of.....	26	Window-glass discovered at Pompeii.....	56
United States, time of fining in the glass houses of.....	44	Window-glass, English, constituents of.....	42
United States, time of melting in the glass houses of.....	44	Window-glass, extent of use of, by the ancients.....	56
Ure's definition of glass (note).....	19	Window-glass factories, definition of.....	1
Ure's classification of glass (note).....	20	Window-glass found at Pompeii, analysis of.....	56
Use of flint in manufacture of glass.....	24	Window-glass, French, constituents of.....	42
Use of glass in ancient Rome.....	62	Window-glass in Germany, early manufacture of.....	63
Use of quartz in manufacture of glass.....	24	Window-glass known to the ancients.....	56
Use of window-glass by the ancients, extent of.....	56	Window-glass, largest size of, made.....	51
Uses of soluble glass.....	21	Window-glass manufacture in Europe.....	71
Uses of water glass.....	21	Window-glass, method of manufacture of.....	50
<b>V.</b>		Window-glass, method of manufacture of ancient.....	56
Varee of Bretagne.....	31	Window-glass, number of boxes made.....	10
Variability of composition.....	19	Window-glass, Pittsburgh, constituents of.....	42
Varieties of Egyptian glass.....	60	Window-glass, price of, in 1797.....	83
Variety of early glass.....	34	Window-glass, product of, value of.....	9, 10
Variety of glass found in tombs at Poitiers.....	63	Window-glass, proportion of materials used in the manufacture of.....	42
Variety of Roman glass.....	62	Window-glass, relative productive rank of the states in.....	9
Vases de verre, manufacture of, in France.....	66	Window-glass, Siemens' tank furnaces for, illustration of.....	39
Vehicles used in glass works.....	5	Window-glass, size of.....	20, 51
Venetian glass.....	70	Window-glass, time of melting in English houses.....	44
Venetian glass-making, early.....	65	Window-glass used in Great Britain in the Roman period.....	56
Venetian glass-making, revival of.....	65	Window-glass, early use of.....	56
Venetian glass manufacture.....	76	Window-glass works, early, in England.....	56
Venice, glass-head manufacture in.....	70	Window-glass works, furnaces in, number of.....	3
Venice, influence of, on modern glass-making.....	64	Window-glass works in the United States in 1787.....	83
Venice, influence of, on the manufacture of English glass.....	68	Window-glass works, pots in, number of.....	3
Venice, modern glass-making dates from.....	64	Women, number of, in glass factories.....	6
Vermont, history of glass-making in.....	97	Women, work of, in glass factories.....	6
Virginia, Captain Norton sent to, to make glass.....	78	Wood ashes, potash made from.....	32
Virginia, history of glass-making in.....	77, 78	Wood furnaces, number of.....	4
Virginia, manufacture of beads in.....	78	Wood used, amount of.....	18
<b>W.</b>		Work of children in glass factories.....	5
Wages, annual settlement of.....	8	Work of women in glass factories.....	5
Wages paid.....	6	Work of youths in glass factories.....	5
Wages, range of.....	6, 7	Works building in census year, statistics of.....	3, 13, 14
Wagons in glass factories, number of.....	4, 5	Works idle in census year, statistics of.....	2, 13, 14
Washing sand, method of, to remove impurities (note).....	24	<b>Y.</b>	
Washington, presentation of flint goblets to, by Mr. Amelung.....	95	Youths, number of, in glass factories.....	5
Water glass (note).....	20	Youths, work of, in glass factories.....	5
Water glass, definition of.....	21		